

***SAMPLING/MONITORING RADIOACTIVE PARTICULATES, TRITIUM,  
AND GASES FROM EXHAUST STACKS, VENTS, AND DUCTS***

**Purpose** This Air Quality Group procedure prescribes the process for designing and installing systems for sampling radioactive particulates, tritium, and other radioactive gases from exhaust stacks, vents, and ducts.

**Scope** This procedure applies to the all LANL exhaust stacks, vents, and ducts that require sampling in accordance with 40 CFR 61.93(b)(2). This procedure also considers DOE requirements for sampling and monitoring in accordance with DOE Order 6430.1A or DOE Orders 5400.1 and 5400.5.

**In this procedure** This procedure addresses the following major topics:

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## General information

**Attachments** This procedure has the following attachments:

Number	Attachment Title	No. of pages
1	ESH-17-121-01, Process	1
2	ESH-17-121-02, Sampling/Monitoring Requirements	1
3	ESH-17-121-03, Sampler/Monitor	1
4	ESH-17-121-04, Ventilation System	2
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10	ESH-17-121-10, Alternate Cyclonic Flow Analysis	1
11	ESH-17-121-11, Flow Measurement Location	2
12	ESH-17-121-12, Sample Extraction Methodology	3
13	ESH-17-121-13, Flow and Mixing Characteristics	1
14	ESH-17-121-14, Engineering Studies	1
15	ESH-17-121-15, ANSI Sample Probe	2
16	ESH-17-121-16, Single-Point Shrouded Sample Probe	2
17	ESH-17-121-17, Transport Line Design	2
18	ESH-17-121-18, Transport Line Design (optimum dia.)	1
19	ESH-17-121-19, Transport Line Design (total penet.)	1
20	ESH-17-121-20, Vacuum System	1
21	ESH-17-121-21, Installation Inspection Checklist	2
22	ESH-17-121-19, Sampling/Monitoring Documentation Checklist	2
23	ESH-17-121-23, Continuation Page	1
24	ESH-17-121-24, Variance Request	1

## History of revision

This table lists the revision history and effective dates of this procedure.

Revision	Date	Description Of Changes
0	1/3/96	New document.

## General information, continued

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**Who requires training to this procedure?** The following personnel require training before implementing this procedure:

- Emissions Measurement Team Leader.
- Emissions Measurement Team members responsible for stack sampling/monitoring system installations and upgrades.

Annual retraining is required and will be self-study.

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**Training method** The training method for this procedure is "self-study" and is documented in accordance with the procedure for training (ESH-17-024).

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**Prerequisites** In addition to training to this procedure, the following training is also required prior to performing Section E of this procedure:

- Use of DEPOSITION 2 Computer Software Code
- Training to procedure ESH-17-102, "Determination of Release Point Potential Effective Dose Equivalent"

## General information, continued

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### Definitions specific to this procedure

Aerodynamic Equivalent Diameter (AED): diameter of a unit-density sphere having the same gravitational-settling velocity as the particle in question.

aerosol: an assembly of liquid or solid particles suspended in a gaseous medium long enough to be observed and measured; generally, about 0.001 - 100  $\mu\text{m}$  in size.

anisokinetic: a condition which prevails when the velocity of air entering a sampling probe or collector when held in the air stream is different from the velocity of the air stream being sampled at that point.

ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers.

aspiration efficiency: fraction of particles entering an inlet from the ambient environment.

Brownian motion: random motion of particles due to collisions with gas molecules.

coefficient of variation (COV): the ratio of the standard deviation of a data set to the mean of the data set.

HEPA Filter: High-Efficiency Particulate Air filter. HEPA filters have a minimum particle removal efficiency of 99.97% (LANL tests to 99.95%) for particles with an AED of 0.3  $\mu\text{m}$ .

isokinetic sampling: sampling condition in which the air flowing into an inlet has the same velocity and direction as the ambient air flow.

isokinetic (near isokinetic) sampling: sampling condition in which the air flowing into an inlet has the same or slightly lower velocity and direction as the ambient air flow.

log-normal size distribution: particle size distribution characterized by a bell-shaped or Gaussian distribution shape when plotted on a logarithmic scale.

MEI: Maximum Exposed Individual.

## General information, continued

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### Definitions continued

monitoring: a measurement system in which the detector is used to continuously measure the radioactivity of an extracted sample of the effluent stream. This may involve either gross radioactivity measurements or specific radionuclide measurements.

monodisperse: composed of particles with a single size or a small range of sizes.

PEDE: potential effective dose equivalent.

representative: faithfully showing the quality and characteristics of the entire volume from which the sample is drawn.

rotometer: a device used to measure the flow rate, as indicated by the height of a float centered in a vertical tapered tube.

sampling: a procedure in which the radionuclides are removed from an extracted sample of the effluent using a collection media. These collection media include filters, absorbers, bubblers and condensers.

SARs: Safety Analysis Report.

subisokinetic sampling: sampling condition in which the air flowing into an inlet has a lower velocity than the ambient air flow.

superisokinetic sampling: sampling condition in which the air flowing into an inlet has a higher velocity than the ambient air flow.

TSRs: Technical Safety Requirement.

transmission ratio: the ratio of the particle concentration delivered by the probe at the entrance of the sample transport line to the free-stream particulate concentration.

## General information, continued

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### References

The following documents are referenced in this procedure:

- 40 CFR 61 Subpart H, “National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities.”
- American Conference of Governmental Industrial Hygienists, *Industrial Ventilation*, 21st Edition.
- Anand, N. K., A. R. McFarland, F. S. Wong, and C. J. Kocmoud, “DEPOSITION: Software to Calculate Particle Penetration Through Aerosol Transport Systems,” NUREG/GR-0006 (Texas A&M University, College Station, Texas, March 8, 1993).
- ANSI N13.1 - 1969, “Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities.”
- DOE Order 6430.1A, *General Design Criteria* (Department of Energy, Washington, D.C.).
- ESH-17-024, “Personnel Training and Orientation.”
- ESH-17-102, “Determination of Release Point Potential Effective Dose Equivalent.”
- ESH-17-104, “Measuring Particulate Mixing In A Stack or Duct.”
- ESH-17-105, “Measuring Gas Mixing In A Stack or Duct.”
- JCI Maintenance Operating Instruction (MOI) 41-30-009, “Exhaust Stack Air Flow Measurements.”
- LANL Alternative Methods Package, July 25, 1994.
- McFarland, Andrew R., and John C. Rodgers, “Single-Point Representative Sampling with Shrouded Probes,” Los Alamos National Laboratory Report LA-12612-MS (August 1993).
- Method 1: EPA 40 CFR 60 Appendix A Test Method, “Sample And Velocity Traverses For Stationary Sources.”

## General information, continued

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### References continued

- Method 1A: EPA 40 CFR 60 Appendix A Test Method, “Sample And Velocity Traverses For Stationary Sources With Small Stacks Or Ducts.”
- Method 2: EPA 40 CFR 60 Appendix A Test Method, “Determination Of Stack Gas Velocity And Volumetric Flow Rate (Type S Pitot Tube).”
- Method 2C: EPA 40 CFR 60 Appendix A Test Method, “Determination Of Stack Gas Velocity And Volumetric Flow Rate In Small Stacks Or Ducts (Standard Pitot Tube).”
- Method 114: EPA 40 CFR 61 Appendix B, “Test Methods For Measuring Radionuclide Emissions From Stationary Sources.”EPA Letter dated November 21, 1994 (Alternative Method Approval).
- EPA Letter dated June 15, 1995 (Alternative Method Approval Clarification).
- EPA Letter dated June 21, 1995 (Re: Single-Point Shrouded Probe Alternative to Radionuclide Emission Measurement Protocols Specified at National Emission Standards for Hazardous Air Pollutants 40 CFR 61.93(b)(1) and (2)).

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### Note

Actions specified within this procedure, unless preceded with "should" or "may", are to be considered mandatory guidance (i.e., "shall").

## Background

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**Introduction** The standard set forth in 40 CFR 61 Subpart H states that “Emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive, in any year, an effective dose equivalent of 10 mrem/yr.” To determine compliance with this standard, LANL must measure radionuclide emission rates from point sources in accordance with the requirements outlined in 40 CFR 61.93.

This procedure prescribes the steps that must be performed to design and install both sampling and monitoring systems to collect representative samples of particulate, tritium and/or gaseous radioactive emissions from stationary point sources. This procedure is intended to ensure compliance with the following:

- 40 CFR 61 Subpart H, “National Emissions Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities.”
- ANSI N13.1 - 1969, “Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities.”
- DOE Orders 5400.1, *General Environmental Protection Program*, and 5400.5, *Radiation Protection of the Public and the Environment*.
- DOE Order 6430.1A, *General Design Criteria*.
- EPA Approved Alternative Sampling Methods (Record Package ESH-17:95-662).

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**Applicability** Follow this procedure to design and/or install a system to sample or monitor all particulate, tritium, and gaseous effluents that result in a potential effective dose equivalent (PEDE) of 0.1 mrem per year or greater (per ESH-17-102) to the release point’s MEI, or where sampling is required by DOE Order (e.g., nuclear facilities). Use this procedure as a *guide* when designing and/or installing a system to sample or monitor particulate or gaseous radioactive effluents that result in a PEDE of less than 0.1 mrem per year.



## Background, continued

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### Exceptions

Because efficient sampling of a facility's radioactive exhaust effluent is as much an art as a science, deviations from this standard are allowed. To obtain approval to deviate from this standard:

- document the reason(s) for the variance, the technical adequacy of the alternative, and the legal justification for the exceptions on Form ESH-17-121-24, Variance Request; and
- obtain approval from the ESH-17 Group Leader.

## A. Sampling/Monitoring Requirements

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**Background** Radionuclide air emission samples must be collected and measured using procedures based on the principles of measurement described in 40 CFR 61 Appendix B, Method 114. Use of methods based on principles of measurement different from those described in Method 114 must have prior approval from EPA.

Method 114 provides the requirements for stack monitoring and sample collection methods appropriate for radionuclides. Radionuclides released from LANL facilities differ in their chemical and physical forms, half-lives, and type of radiation emitted. The appropriate combination of sample extraction, collection, and analysis for an individual radionuclide is dependent upon many interrelated factors including the mixture of other radionuclides present. Because of this wide range of conditions, no single method for monitoring or sample collection and analysis for a radionuclide is applicable to all facilities.

Section A (of this procedure), Sampling/Monitoring Requirements, is intended to gather information about facility operations and to specify appropriate sampling and monitoring methods. Before completing this section, you must complete ESH-17-102, "Determination of Release Point Potential Effective Dose Equivalent." ESH-17-102 prescribes the process to calculate the PEDE to determine if stack monitoring is required. If monitoring is required, complete Section A.1 to document the facility processes that generate the radioactive air emission. By knowing the facility process and radioactive inventory, sampling and monitoring requirements can be specified in Section A.2. Finally, use the sampling and monitoring requirements to specify the sampler and/or monitor in Section A.3.

## A.1 Process

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**Form**

Document your work on form ESH-17-121-01.

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**Applicability**

Complete Section A.1 to document the facility process(es) which generate radioactive emissions.

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**Step 1  
Description of  
the process**

Describe in detail the process which generates radioactive exhaust stack effluents.

Include such things as: 1) type(s) of operations (laboratory, manufacturing, etc.); 2) the process (grinding, cutting, sanding, crushing, etc.); 3) additives (moisture, heat, chemicals, etc.). Attach schematics, diagrams, and flow charts if available.

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**Step 2  
Contaminants  
generated by  
the process**

Indicate what type (form) of contaminants are generated by the process.

Particulates: If the process generates particulate, what size range is expected? If inertial size particles ( $> 3 \mu\text{m}$ ) are expected, give consideration to inertial sampling requirements (isokinetic sampling or single point shrouded probe) when designing a sampling system. If particles  $> 15 \mu\text{m}$  are generated, additional considerations may be required for single-point sampling.

Gases: If the process generates gases, are they condensable, non-condensable, or reactive? If the gases are condensable, determine the sample line temperature exposure range. Determine if heat tracing is required to prevent the gases from condensing in the sample line and distorting the sample. If reactive gases are expected, select appropriate non-reactive sample probe and transport line materials.

Corrosives: List any corrosives expected in the effluent. Select appropriate corrosion resistant sample probe and transport line materials.

## Process, continued

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### Step 3 Exhaust air parameters

Record the expected temperature and humidity of the exhaust effluent.

Temperature: Indicate the expected temperature range in degrees C for the facility effluent. Use the temperature range to select which version of DEPOSITION to use to optimize the sample line size.

$$^{\circ}\text{C} = 5/9(^{\circ}\text{F} - 32)$$

$$^{\circ}\text{F} = 1.8 ^{\circ}\text{C} + 32$$

Humidity: Indicate the expected relative humidity (% RH) for the facility effluent. If the facility effluent is essentially ambient air, 0% RH may be assumed (ESH-17: 95-739, "Exhaust Stack Volumetric Flow Rate and Sample Flow Rate Reporting"). Note: JCI flow measurement results are calculated assuming dry effluent air.

## A.2 Sampling/Monitoring Requirements

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**Form** Document your work on form ESH-17-121-02.

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**Applicability** Complete Section A.2 to specify sampling and monitoring requirements. Use this information in Section A.3 to determine sampling and monitoring methods.

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**Step 1  
PEDE** Indicate the exhaust stack PEDE determined from procedure ESH-17-102.  
Record the date of the review.

- Is sampling required?

If the  $PEDE \geq 0.1$  mrem/yr, then sample the effluent in accordance with 40 CFR 61 Subpart H.

- Is monitoring required?

If real-time monitoring is required, annotate the reason and the requirement reference (e.g., facility SAR) in the justification block.

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**Step 2** Indicate which forms of radionuclides present require sampling.

**Sampling  
requirements**

40 CFR 61 Appendix B Method 114, Test Methods For Measuring Radionuclide Emissions From Stationary Sources, provides the requirements for collecting and monitoring radionuclides.

- Particulate: Radionuclides of most elements will be in the particulate form.
- Tritium: Radionuclides of hydrogen will be in the gaseous or water vapor form. Tritium is included in Method 114 under gases, but is treated separately at LANL.
- Gases: Radionuclides of oxygen, carbon, nitrogen, the noble gases and in some circumstances iodine will be in the gaseous form. Volatiles are also included in this category.

## Sampling/Monitoring Requirements, continued

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### Step 3 Monitoring Requirements

Indicate which forms of radionuclides present require real-time monitoring and what type of radioactivity to monitor.

Install real-time monitors on stacks which require redundant monitoring in accordance with DOE 6430.1A, *General Design Criteria*. In addition, EPA allows real-time monitoring as an acceptable method to quantify emissions for some gases listed in step 2. For short-lived radionuclides, real-time monitors may be the only realistic sampling option.

## A.3 Sampler/Monitor

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**Form** Document your work on form ESH-17-121-03.

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**Applicability** Complete Section A.3 to specify what samplers and/or monitors to install.

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**Step 1  
Sampling  
collection  
methods** If sampling is required, specify what sample collection method and/or monitor to install. Be specific. Include the instrument(s) and the model number(s) or drawing number. Attach a specification sheet if available.

Particulates:

- Pass the extracted effluent stream through a filter media to remove the particulates. Follow the guidance in 40 CFR 61, Appendix A, Method 114 (ANSI N13.1-1969) in using filter media to collect particles.
- Use ESH-17 filter housings. Refer to ESH-17 drawing 142Y-004 detail D1, D2, or D3. Select the filter housing size appropriate for the sample probe and the transport line.

Tritium:

- Tritium in the form of water vapor is collected from the extracted effluent sample by sorption, condensation, or dissolution techniques. Appropriate collectors include silica gel, molecular sieves, and ethylene glycol or water bubblers. Tritium in the elemental form may be measured directly, or collected and oxidized using a metal catalyst to tritiated water.
- Use the EG&G Labersso EL700 tritium bubbler to meet all point source sampling requirements. Install the EL700 bubbler on all stacks that require tritium sampling (see Section A.2). ESH-4 will test and calibrate the EL700 bubbler. Obtain formal approval from the ESH-4 Radiation Instrument Calibration (RIC) section for any post-production modifications to the EL700 bubbler. If approved and appropriate, direct RIC to perform these modifications.
- Silica gel may be used to collect tritium where only tritium oxide is expected (i.e., no elemental tritium).

## Sampler/Monitor, continued

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**Sampling  
collection  
methods  
(continued)**

Gases:

- Iodine: Iodine is collected from an extracted sample by sorption or dissolution techniques. Appropriate collectors may include charcoal, impregnated charcoal, metal zeolite, and caustic solutions.
- Argon, Krypton and Xenon: These elements are either measured directly with a real-time monitor, or are collected from the sample by low temperature sorption techniques.
- Oxygen, Carbon, Nitrogen, and Radon: These elements are measured directly with a real-time monitor. Carbon, in the form of carbon dioxide, may be collected by dissolution in caustic solutions.
- Volatiles: The gaseous form of these materials, which are liquids or solids at room temperature, are collected using charcoal filters. (Vapors are gases, but are assumed to have been released or volatilized from liquids or solids.)



## Sampler/Monitor, continued

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### Step 3 Monitoring methods

If monitoring is required, specify what monitoring system to install.

#### Particulates:

- Use Continuous Air Monitors (CAMs) approved by ESH-4.

#### Tritium:

- Use the femto-Tech model 224GB/U24 to perform real time monitoring. Use real time monitoring for stacks that required redundant monitoring in accordance with the facility's TSRs or DOE 6430.1A, *General Design Criteria*. Active alarm limits, which nominally fall between 20 and 50  $\mu\text{Ci}/\text{m}^3$ , will be coordinated and set independently for each operational facility. Both local alarms and centrally located remote alarms with audible and visual annunciation are advisable. Recording capability of the alarm output is highly advisable. ESH-4 will test and calibrate the 224GB/U24 femto-Tech monitors. Obtain formal approval from the ESH-4 Radiation Instrument Calibration (RIC) section for any post-production modification to the 224GB/U24 femto-Tech monitors. If approved and applicable, direct RIC perform this modification.

#### Gases:

- Use commercially available continuous air monitors approved by ESH-4 when feasible. If a commercial instrument is not available, specialized continuous air monitors may be built (e.g., the gaseous emissions monitor for TA-53-0003-03).

## B. Ventilation System

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**Background** LANL ventilation systems are composed of laboratory hoods, glove boxes, ductwork, pollution control devices, fans, and the exhaust stack or vent. Ventilation systems are critical for providing both worker safety and environmental protection. System design and construction determines what challenges you will encounter when designing and installing a stack or duct sampling/monitoring system.

The information collected in Section B is necessary to design and install an effective sampling and/or monitoring system. This information is also necessary to calculate radioactive air emissions that are reported to EPA. Complete Section B.1 to summarize the ventilation system. Complete Sections B.2, B.3, and B.4 to provide detailed information about the pollution control devices, fan exhausts, and exhaust stack.

## B.1 Ventilation System

<b>Form</b>	Document your work on form ESH-17-121-04.
<b>Applicability</b>	Complete Section B.1 to document the ventilation system. This information will be entered into the ESH-17 facility database. ESH-17 will use the information generated from this interface to monitor LANL compliance with 40 CFR 61 Subpart H and to review new project requests.
<b>Step 1 As-built drawings</b>	<p>Are ventilation system drawings listed in the ESH-17 as-built drawing database? If yes, attach a list of the drawings from the database. If no, obtain drawings from FSS and load drawing information into the ESH-17 as-built drawing database.</p> <p><b>Note:</b> Ensure that drawings are appropriately marked (i.e., UCNI).</p>
<b>Step 2 Pollution control devices</b>	<p>Are pollution control devices used in the ventilation system?</p> <p>If yes, complete Form ESH-17-121-05 for each pollution control device.</p>
<b>Step 3 Fan(s)</b>	Indicate the number of fan exhausts and list them by FE number. Attach Form ESH-17-121-06 for each fan exhaust.
<b>Step 4 Fan configuration</b>	<p>Indicate all possible ventilation system configurations. For each configuration, give the speed setting and on/off status for each fan exhaust.</p> <p><b>Example:</b> CF-1: FE-1/On/High-Speed. FE-2/Off. FE-3/On/Variable-Speed. If there are adjustable dampers used to control flow, indicate their settings. CF-1 should be the configuration used for EPA reporting.</p>
<b>Step 5 Exhaust stack</b>	<p>Indicate how the effluent discharges (i.e., vertical, horizontal, or other) into the environment. Complete Form ESH-17-121-07.</p> <p>‘Other’ discharges would include ‘J’ vents, etc.</p>

## Ventilation System, continued

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### Step 6

#### General description of ventilation system

Provide a general description of the ventilation system.

Include how the fan exhausts, pollution control devices, and exhaust stack are connected.

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### Step 7

#### Detailed description of ventilated areas

Provide a detailed description of the ventilated areas.

Document this information in a tree format. **Example:** Exhaust Stack -- Fan Exhaust -- Pollution Control Device -- Wing/Room Number/etc.

Annotate what type of inlet (i.e., glove box, room exhaust, welding hood, etc.) is on the system. This information will be entered into the ESH-17 facility database.

## B.2 Pollution Control Devices

<b>Form</b>	Document your work on form ESH-17-121-05.
<b>Applicability</b>	Complete Section B.2 for each installed pollution control device. Use one form for each device. Do not include glove box or hood HEPA filters used to reduce duct hold-up.
<b>Step 1 Device number</b>	Indicate the pollution control device number.  Use the pollution control device number that ESH-5 has assigned for testing.
<b>Step 2 Fan exhaust</b>	Indicate the fan exhaust connected to the pollution control device. Indicate 'other' FE's if more than one are used.
<b>Step 3 Pollution control method(s)</b>	Indicate the type of pollution control device.  There are many methods to control effluent releases. As an example, for particulates, there is filtration, cyclonic devices, electrostatic precipitators, etc. HEPA filtration is the most common pollution control device used to control particulate radionuclide emissions. ASHRAE 52 filters are also used. If pollution control devices other than filtration are employed, provide a detailed description in step 6.
<b>Step 4 Test frequency</b>	Indicate the pollution control device acceptance test frequency.
<b>Step 5 Test results (last three)</b>	Record the last 3 test results. Indicate the date of the test, whether the system passed or failed, and the standard (i.e., penetration of less than 0.05% of 0.3 $\mu\text{m}$ AED particles).  ESH-5 performs routine periodic testing of pollution control devices.

## Pollution Control Devices, continued

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**Step 6** Provide a detailed description of the pollution control system if either  
**Description** 'Filtration - Other' or "Other" is selected in Step 3.

## B.3 Fan Exhaust(s)

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**Form** Document your work on form ESH-17-121-06.

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**Applicability** Complete Section B.3 for each fan exhaust. Use one form for each fan exhaust in the ventilation system.

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**Step 1**  
**Fan exhaust** List the fan exhaust number.

Old “Class A” fans have an FSS-assigned FE number. “Class B”, or Operating Group property, fans may, or may not, have an FE number.

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**Step 2**  
**Fan** Record the following information describing the fan exhaust.

Fan Type Axial, centrifugal, or special purpose? Specify the type of fan blade if possible. Propeller, forward curved impeller, radial impeller, or backward curved impeller).

- Manufacturer
- Model Number
- Serial Number (SN)
- Dampers - Does the fan have inlet or outlet dampers?
- Turning Vanes - Are turning vanes installed on the outlet of the fan?
- Fan Outlet Exhausts - How is the fan outlet is oriented (overhand, underhand, or vertical)?

This information will be helpful for analyzing any future changes to flow conditions.

## Fan Exhaust(s), continued

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### Step 3 Motor

Record the following information describing the fan motor.

- Motor Type
  - Manufacturer
  - Horsepower (HP)
  - Rating - Electrical rating
  - Revolutions per Minute (RPM)
  - Speed - 1-speed, 2-speed, variable speed, etc?
- 

### Step 4 Comments

Provide any comments. Indicate if none.

If a fan curve is available from the manufacture, attach a copy to this form.



## B.4 Exhaust Stack Height, Elevations, and Exit Parameters

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**Form** Document your work on form ESH-17-121-07.

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**Applicability** Complete Section B.4 to record exhaust stack heights and elevations. This information is used for atmospheric modeling of exhaust stack effluent. It is also used for elevation corrections to the effluent density for flow measurement calculations.

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**Step 1  
Reference  
grade  
elevation (RG)** Record the building reference grade (RG) elevation in feet. Provide a description of the building reference grade elevation and the source of the elevation.

The building reference grade elevation is the height above sea level (in feet) of a selected point on the building. The point selected should be the grade elevation of the building used for air dispersion modeling. This point can be selected from facility as-built drawings or by surveying.

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**Step 2  
Intermediate  
reference  
height(s)** If needed, select an intermediate reference (IR) height(s) (in feet). Describe, in detail, where the point is located.

The intermediate reference height is the height of a point in the building above or below the reference grade elevation location. This point is selected to simplify other measurements (e.g., the basement floor or the roof). If not required, enter the RG.

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**Step 3  
Exhaust stack  
height** Measure the exhaust stack height from the intermediate reference height. Add the intermediate reference height and the stack height from the IR to get the height of the exhaust stack above the building reference grade. Convert the final height, given in feet, to meters. The conversion factor is:

$$\text{feet}/3.28 = \text{meters}$$

This value is the height of the exhaust stack above the building reference grade elevation that is used in air dispersion modeling.

## Stack Height, Elevations, and Exit Parameters, continued

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**Step 4**  
**Exhaust stack exit plane and elevation**

Record whether the exhaust effluent is vented into the atmosphere vertically through a stack, horizontally through a vent, or other way, such as down through a roof ventilator or J-stack.

Determine the exit elevation by adding the building reference grade elevation to the exhaust stack height. This is the exhaust stack height above sea level.

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**Step 5**  
**Exhaust stack exit area**

Calculate the exhaust stack or vent exit area. The area is found by:

Rectangular:  $\text{Area} = \text{length} \times \text{width}$

Circular:  $\text{Area} = \pi(\text{diameter}/2)^2$

The exit area is used to determine the exit velocity for air dispersion modeling.

## **C. Sampling/Monitoring Site Selection**

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**Background**

In accordance with 40 CFR 61.93(b)(2)(i), Reference Method 1 or 1A of Appendix A, Part 60 must be used to select monitoring or sampling sites. Reference Method 1 must be used to determine flow measurement traverse requirements.

Selection of an appropriate sampling site is critical to ensure representative sampling. The selection process outlined in Reference Method 1 for selecting a sampling site specifies criteria based on sample site location and cyclonic flow conditions. Reference Method 1 recommends selecting a sampling location at least 8 duct diameters downstream and 2 duct diameters upstream from any flow disturbance. ANSI N13.1 recommends that this distance be a minimum of 5 and preferably 10 or more duct diameters downstream from any flow disturbance. These “rules-of-thumb,” designed to select a sampling site with minimum flow swirl or rotation (cyclonic flow) and to maximize representativeness of the sample, are not always accurate. To ensure that the site flow conditions are adequate for sampling, cyclonic flow measurements must be made. If the flow and mixing conditions meet EPA approved alternative method criteria, single point sampling may be appropriate (Refer to Section D).

Accessibility and safety are important to consider when selecting a sampling site. Clearance for the sampling and velocity measurement probes, availability of electricity, exposure to weather, excessive heat and radiation, presence of toxic or explosive gases, and other safety factors must be considered when selecting a sampling site. The sampling site access must meet Occupational Safety and Health Act (OSHA) requirements. The construction of permanent scaffolding, safety rails, or ladders may be required. When possible, select a sampling site that is inside an existing structure to protect it from weather. Also, select a sampling site which provides minimum interference with facility operations. If there are multiple sites that meet the requirements of this section, select the site that provides both worker safety with easy access. If engineering or operating considerations preclude a single sampling site, appropriately place sufficient sampling sites to ensure that all radioactive exhaust effluents are sampled.

Select a sampling location on the ventilation system exhaust stack or duct that is downstream from the exhaust fan and all pollution control devices. Using engineering judgment, select a location having a good velocity profile and a good particulate and/or gas mixing profile. Complete the steps in Section C.1 to document your selection. Perform cyclonic flow measurements as indicated in Section C.1 by using either Section C.2 or Section C.3. When a sampling site has been selected, complete Section C.4 to establish a flow measurement location.

## C.1 Site Selection

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**Form** Document your work on form ESH-17-121-08.

---

**Applicability** Complete Section C.1 to select a sample site.

---

**Step 1** Provide a detailed description of the sampling site.

**Describe sampling site** Include both the location of the sampling site within the facility and the location of the sampling site on the ventilation system. Include enough detail so that someone who is not familiar with the system can find the sampling site. Also include helpful information such as who to contact for keys, where portable ladders are located, etc.

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**Step 2** Indicate whether the exhaust stack or duct is round or rectangular. Measure and record the physical dimensions of the exhaust stack or duct at the sampling site.

**Measure sampling/monitoring site physical dimensions** Check the exhaust stack or duct dimensions along at least two traverses. If the dimensions (diameter for round; width and length for rectangular) are within 1/4 inch, use the average dimension. If they are not within 1/4 inch, record each measurement for each dimension because spacing on each traverse will have to be determined separately. Round all measurements to the nearest 1/8-inch. For rectangular stacks, we will define the length as the dimension into the stack or duct and the width as the dimension perpendicular to the drilled holes.

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**Step 3** For rectangular exhaust stacks and ducts, calculate the equivalent duct diameter ( $D_e$ ).

**Calculate the rectangular equivalent diameter**

$$D_e = \frac{2LW}{(L + W)}$$

## Site Selection, continued

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**Step 4**  
**Calculate the**  
**sampling/**  
**monitoring**  
**site cross-**  
**sectional area**

Using the recorded dimensions from Step 2, calculate the sample site cross-sectional area.

$$A_{\text{Rectangle}} = \frac{(\text{width}) \times (\text{length})}{144} \quad \text{and} \quad A_{\text{Circle}} = \pi \left( \frac{\text{diameter}}{24} \right)^2$$

where A is given in ft<sup>2</sup>, and the width, length, and diameter are in inches.

The sample site cross-sectional area is used to determine volumetric flow rates.

---

**Step 5**  
**Measure the**  
**distance from**  
**the sampling**  
**site to the**  
**nearest flow**  
**disturbances**

Measure and record the distances from the sampling site to the nearest upstream and downstream flow disturbance.

A flow disturbance is anything in the stack or duct which can distort the flow. Bends, expansions, contractions, tees, and open flames are examples of flow disturbances.

Upstream is defined as going into the direction of the flow.

Downstream is defined as going with the direction of the flow.

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**Step 6**  
**Calculate the**  
**duct diameter**  
**ratio from the**  
**sampling site**  
**to the flow**  
**disturbances**

Calculate the Duct Diameter (DD) ratio from the sampling site to both the upstream and downstream flow disturbance.

The Duct Diameter (DD) ratio is defined as the ratio of the distance from the sampling site to the flow disturbance (inches) divided by the equivalent duct diameter (inches).

## Site Selection, continued

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**Step 7**  
**Method 1**  
**traverse**  
**requirements**

Using the results from step 5, select a category for the sampling site location.

Category 1:  $DD_{Up} \geq 8$  and  $DD_{Down} \geq 2$ .

A sampling site should be located at least 8 stack or duct diameters downstream and 2 stack or duct diameters upstream from a flow disturbance. If a sampling site meets this criteria, then you may use a minimum of 8 traverse points for round stacks or 9 traverse points for rectangular stacks for velocity traverses. We have decided to use the conservative values from Method 1 Figures 1-1 and 1-2. These values are 2 x 12 and 5 x 5 for round and rectangular flow measurement traverses, respectively. Go to Step 8.

Category 2:  $[2 \leq DD_{Up} < 8$  and  $DD_{Down} \geq 1/2]$  or  $[DD_{Up} \geq 2$  and  $1/2 \leq DD_{Down} < 2]$

If necessary, an alternate location may be selected at a position at least 2 stack or duct diameters downstream and 1/2 stack or duct diameters upstream from a flow disturbance. Method 1 Figure 1-1 or 1-2 must be used to determine the minimum number of traverse points for velocity traverses. We have selected the conservative values from Figures 1-1 and 1-2. The conservative values require 2 x 12 and 5 x 5 flow measurement traverses for round and rectangular, respectively. Go to Step 8.

Category 3:  $DD_{Up} < 2$  or  $DD_{Down} < 1/2$

Method 1 Section 2.5 provides an alternate procedure for determining the acceptability of a site location that fits this criteria. The flow measurement traverse requirements are given in Method 1 Section 2.5 and JCI MOI 41-30-009. Go to Step 9.

## Site Selection, continued

<b>Step 8</b> <b>Perform</b> <b>cyclonic flow</b> <b>analysis</b>	Instruct JCI to perform a cyclonic flow measurement per procedure MOI 41-30-009 at the sampling site using the traverses specified in Step 7. Complete Section C.2 and record the results of this measurement on Form ESH-17-121-09. Indicate if the cyclonic flow conditions are acceptable. If the cyclonic flow conditions are acceptable, go to step 10. If the cyclonic flow conditions are not acceptable, another sampling site must be selected or the flow must be conditioned to achieve acceptable flow conditions.
<b>Step 9</b> <b>Perform</b> <b>Alternative</b> <b>Cyclonic Flow</b> <b>Analysis</b>	Instruct JCI to perform an alternate cyclonic flow measurement per procedure MOI 41-30-009 at the sampling site using the traverses specified in Step 7. Complete Section C.3 and record the results of this measurement on Form ESH-17-121-10. Indicate if the cyclonic flow conditions are acceptable. If the cyclonic flow conditions are acceptable, go to step 10. If the cyclonic flow conditions are not acceptable, another sampling site must be selected or the flow must be conditioned to achieve acceptable flow conditions.
<b>Step 10</b> <b>Acceptability</b> <b>of sampling</b> <b>site</b>	<p>If directed to this step from either step 8 or step 9, then the sampling site is acceptable according to EPA Method 1 site selection criteria.</p> <p>Note that this site selection criteria is not performance based. To qualify a site for single point sampling, additional criteria must be met for mixing and flow performance. These additional criteria are covered under Section D, Sample Extraction.</p>
<b>Step 11</b> <b>Comments</b>	Include any comments or information about the sample site or sample site selection process. If no comments are provided, check none.



## C.2 Cyclonic Flow Analysis

<b>Form</b>	Document your work on form ESH-17-121-09.
<b>Applicability</b>	Complete Section C.2 if required from Section C.1 to evaluate cyclonic flow conditions at the sampling site.
<b>Step 1 Measure the average cyclonic flow rotation angle</b>	<p>Record the average cyclonic flow rotation angle. Indicate the JCI flow report date.</p> <p>Cyclonic flow measurements are performed by JCI in accordance with JCI procedure MOI 41-30-009.</p>
<b>Step 2 Determine the acceptability of sampling site based on cyclonic flow conditions</b>	<p>Indicate whether the sampling site meets or does not meet Method 1 cyclonic flow condition criteria.</p> <ul style="list-style-type: none"><li>• Meets: The average rotation angle is less than or equal to 20 degrees.</li><li>• Does Not Meet: The average rotation angle is greater than 20 degrees.</li></ul> <p>If the sampling site does not meet the Method 1 cyclonic flow condition criteria, then either select another sampling site or condition the flow. In either case, document the unacceptable sampling site for future reference.</p>
<b>Step 3 Flow conditioning</b>	Indicate if flow conditioning devices are installed. If flow conditioning is used, fully describe the flow conditioning system.

## C.3 Alternative Cyclonic Flow Analysis

<b>Form</b>	Document your work on form ESH-17-121-10.
<b>Applicability</b>	Complete Section C.3 if required from Section C.1 to evaluate cyclonic flow conditions at the sampling site.
<b>Step 1 Sampling site</b>	<p>Complete this section to determine if the alternative sampling site selection procedure can be used. The sampling site must be: a) either less than 2 stack or duct diameters downstream or less than 1/2 stack or duct diameters upstream from a flow disturbance; <u>and</u> b) the duct diameter (equivalent) must be greater than 24 inches.</p> <p>If both of these criteria are met, then perform cyclonic flow measurements in accordance with Method 1 Section 2.5 using JCI procedure MOI 41-30-009.</p> <p>If either of these criteria are not met, then you may use additional procedures to qualify the sampling site with prior EPA approval. Go to step 4.</p>
<b>Step 2 Alternative site selection procedure</b>	Indicate whether Method 1 Section 2.5 (JCI MOI 41-30-009) alternative cyclonic flow procedures or some other cyclonic flow procedure is used. If the Method 1 Section 2.5 procedure is used, go to section 3. If some other procedure is used, go to section 4.
<b>Step 3 Method 1, Section 2.5</b>	<p>Record the results from JCI MOI 41-30-009 cyclonic flow measurements. If the average resultant angle is less than or equal to 20 degrees and the standard deviation is less than or equal to 10 degrees, then the site is acceptable. If the site is unacceptable, select another location.</p> <p>The average resultant angle and the standard deviation are defined in Method 1, Section 2.5.4.1.</p>
<b>Step 4 Other Cyclonic Flow Measurement Methods</b>	Document the cyclonic flow method used. Include references to research, supporting documents, and EPA approvals for this method.

## C.4 Flow Measurement Location

<b>Form</b>	Document your work on form ESH-17-121-11.
<b>Applicability</b>	Complete Section C.4 and send a copy to JCI/MDES to establish routine flow measurements.
<b>Step 1 Description of the flow measurement location</b>	<p>Describe the flow measurement location in detail.</p> <p>The flow measurement location must be just upstream from the sampling site selected in Section C.1. If the exhaust stack or duct is less than 12 inches in diameter, the flow measurement location must be at least 2 duct diameters downstream from the sampling site, and 1/2 diameter upstream from any flow disturbance. If possible, the flow measurement location should be at least 8 duct diameters downstream from the sampling site and at least 2 duct diameters upstream from any flow disturbance.</p>
<b>Step 2 Flow measurement location physical dimensions</b>	<p>Record the flow measurement location physical dimensions.</p> <p>These should be the same as item 2 on Form ESH-17-121-08. If these dimensions are not the same, indicate this in the comment section.</p> <p>This information is necessary to determine correct traverse spacing.</p>
<b>Step 3 Flow measurement location cross- sectional area</b>	<p>Record the flow measurement location cross-sectional area. This value should be the same as item 4 on Form ESH-17-121-08. If this dimension is not the same, indicate this in the comment section.</p> <p>This information is necessary to determine the actual volumetric flow rate.</p>

## Flow Measurement Location, continued

<b>Step 4 Flow measurement location elevation</b>	<p>Record the flow measurement location elevation.</p> <p>This is the elevation above sea level. To determine this elevation, measure the height of the flow measurement location above the intermediate reference height defined in Step 2 on Form ESH-17-121-07. Add this height and the intermediate reference height to the reference grade elevation.</p> <p>This information is necessary to adjust the exhaust stack effluent's density for elevation.</p>
<b>Step 5 Method 1 traverse requirements</b>	<p>Indicate which category the flow measurement location is in.</p> <p>This determines the flow measurement traverse requirements. This category should be identical to the sample site.</p> <p>This information is necessary to determine the flow measurement matrix.</p>
<b>Step 6 Spacing</b>	<p>Use the appendices in JCI procedure MOI 41-30-009 to determine the traverse spacing requirements.</p>
<b>Step 7 Comments</b>	<p>Record any comments concerning the flow measurement location. If no comments are provided, check none.</p>

## D. Sample Extraction

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**Background** In accordance with 40 CFR 61.93(b)(2)(ii), the effluent stream must be directly monitored continuously with an in-line detector or representative samples of the effluent stream must be withdrawn continuously from the sample site following the guidance presented in ANSI N13.1 - 1969, "Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities."

From ANSI N13.1, "Representative particle samples from ducts and large stacks can be assured only by careful selection of the sampling point, with attention given to the design of the probe and sampler arrangement." Further, "A sampling arrangement which, at all times, will ensure a representative sample of all sizes of particles along with the requirements of proper frequency and sensitivity is very difficult to achieve in most cases."

After selecting the sampling site in Section C, Section D.1 provides the steps necessary to select a sample extraction method. From ANSI N13.1, we can employ single-point or multi-point probes sampling either isokinetically or anisokinetically. LANL has also received approval from EPA to use single-point shrouded probes to sample anisokinetically. To assist in completing Section D.1, complete Section D.2, which summarizes the results of Method 2 flow measurements, gas challenges, and aerosol challenges. Document any engineering studies in Section D.3. After completing Section D.1, complete the appropriate Section to specify the sample probe. ANSI type sample probes are covered under Section D.4 and single-point shrouded probes are covered under Section D.5.

## D.1 Sample Extraction Methodology Selection

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**Form** Document your work on form ESH-17-121-12.

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**Applicability** Complete Section D.1 to determine how to extract the sample.

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**Step 1** Is the sample site acceptable from Section C.

**Sample site**

If the sampling site is not acceptable, then either another sampling site must be selected or the flow must be conditioned so that the requirements of Section C are met.

---

**Step 2** Are there any low momentum lateral flows entering flush with the wall of the  
**Lateral flow** exhaust stack or duct upstream from the sampling site, but downstream of the main fan(s), whose discharge PEDE could exceed 1% of the 10 mrem standard?

Yes -- The lateral flow must be mixed or otherwise introduced into the mainstream flow.

No -- Sampling site is acceptable.

This requirement is included to preclude the possibility of significant emissions from a secondary flow being trapped in the boundary layer of a primary flow and thereby not being monitored. This applies to flows introduced at a location downstream of the main fan(s) but before the sampling site in a manner where the secondary flow entrance is flush with the wall of the primary flow duct. This does not include junctions where the flow volumes are of approximately the same magnitude, or where static mixing devices have been installed and tested to demonstrate contaminant mixing of the secondary flow with the primary flow.

## Sample Extraction Methodology Selection, continued

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### Step 3

#### Tritium and gaseous radionuclides

Indicate if tritium or gaseous radionuclides are present.

From Form ESH-17-121-13, indicate if the COV is less than or equal to 20% for the inner 2/3 area.

Yes -- Sampling site is acceptable for single point anisokinetic sampling.

No -- Sampling site is not acceptable for single point anisokinetic sampling. Go to Step 6.

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### Step 4

#### Particulate radionuclides

Indicate if particulate radionuclides are present.

- a) From Form ESH-17-121-13, indicate if the velocity profile COV is less than or equal to 20% for the inner 2/3 area.

Yes -- Go to step 4.b.

No -- Site is not acceptable for single-point sampling. Go to Step 6.

- b.1) From Form ESH-17-121-13, indicate if the gas profile COV is less than or equal to 20% for the inner 2/3 area.

Yes -- Go to step 4.b.2.

No -- Site is not acceptable for single-point sampling. Go to Step 6.

- b.2) From Form ESH-17-121-13, indicate if, at any point on the profile, the gas concentration is more than 30% greater than the mean concentration across the cross-section.

Yes -- Site is not acceptable for single-point sampling. Go to Step 6.

No -- Go to Step 4.c.

- c) From Form ESH-17-121-13, indicate if the aerosol profile COV is less than or equal to 20% for the inner 2/3 area.

Yes -- Use a single-point anisokinetic sample probe.

No -- Site is not acceptable for single point sampling. Go to Step 6.

## Sample Extraction Methodology Selection, continued

<b>Step 5</b> <b>Comments on</b> <b>deviations</b>	Provide comments for any deviations to the acceptance criteria listed in steps 1 through 4.
<b>Step 6</b> <b>Conservative</b> <b>sample</b>	<p>Is there a location in the cross-section that can provide a conservative sample? Select the appropriate response and indicate if you are sampling for gases or particulates. This gives you the type of sample extraction to use.</p> <p>In instances where the criteria in steps 1 - 4 cannot be satisfied, one of the following courses of action must be taken before single-point sampling can be employed (EPA letter dated June 21, 1995):</p> <ol style="list-style-type: none"><li>1. The exhaust stream mixing will be enhanced by appropriate measures (e.g., installing mixing elements, adding elbows, etc.) to achieve a coefficient of variation that is not greater than 20%, or</li><li>2. A single nozzle probe will be placed in accordance with the velocity and test tracer profiles such that the probe is sampling at a point of above average test tracer concentration.</li></ol>
<b>Step 7</b> <b>Description of</b> <b>conservative</b> <b>sample location</b> <b>and selection</b> <b>process</b>	<p>Provide a detailed description of the conservative sampling location. Explain the sample site selection process. Provide test information to satisfy the EPA CONDITION below. Indicate the stability of the conservative sampling location and what measures will be taken to ensure that the location remains a conservative location.</p> <p>EPA CONDITION: If a Coefficient of Variation <math>\leq 20\%</math> is not achieved by measures described in option (1) and the alternative option (2) is employed, the probe must be placed such that test tracer concentrations are above average for all test particles over the entire design envelope range of 3 - 15 <math>\mu\text{m}</math> aerodynamic equivalent diameter, and this must be documented.</p>
<b>Step 8</b> <b>Sampling rate</b>	Indicate if the sampling rate is near isokinetic or anisokinetic.
<b>Step 9</b> <b>Representative</b> <b>sample</b> <b>collection</b>	Provide comments about the representativeness of the sample.



## D.2 Flow and Mixing Characteristics

<b>Form</b>	Document your work on form ESH-17-121-13.
<b>Applicability</b>	Complete Section D.2 to record flow and mixing characteristics at the sampling site. This information will be used to determine what sample extraction method will be used (i.e., single-point or multi-point, ANSI probe or shrouded probe).
<b>Step 1 Method 2 flow rate measurements</b>	<p>Record the flow measurement results from JCI procedure MOI 41-30-009. Include the measurement date, the average velocity and the actual flow rate. Using ESH-17's Excel spreadsheet program (file name: TRAVNEW.XLS) calculate the COV of the flow profile for both the entire area and the central 2/3 area.</p> <p>From the Excel spreadsheet data, plot the 3-dimensional flow profile and attach it to the flow measurement report.</p>
<b>Step 2 Gas challenge</b>	Record the gas challenge results from ESH-17-105. If no challenge was performed, indicate 'not performed.' Include the measurement date, the ESH-5 report number and date, and the COV of the gas profile for the central 2/3 area. Also indicate if, at any point in the cross-section, the gas concentration is more than 30% greater than the mean concentration from across the exhaust stack or duct cross-section.
<b>Step 3 Aerosol challenge</b>	Record the aerosol challenge results from ESH-17-104. If no challenge was performed, indicate 'not performed.' Include the measurement date, the ESH-5 report number and date, the particle size tested and the COV of the aerosol profile for the central 2/3 area.
<b>Step 4 Comments</b>	Provide any comments concerning these measurements.

## D.3 Engineering Studies

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<b>Form</b>	Document your work on form ESH-17-121-14.
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<b>Applicability</b>	Complete Section D.3 if engineering studies have been performed on the ventilation system to enhance mixing or condition the flow profile.
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<b>Step 1 Description and results of engineering studies performed on ventilation system</b>	Document all known engineering studies performed on the ventilation system. Include any studies and tests performed to accept the system. Include the purpose of the study and the results. Also include report or document numbers, the date the study was performed, and who performed the study.
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## D.4 ANSI Sample Probe

<b>Form</b>	Document your work on form ESH-17-121-15.
<b>Applicability</b>	If you will use an ANSI type sample probe from Section D.1, complete Section D.4.
<b>Step 1 Exhaust stack/duct parameters</b>	<p>Record the exhaust stack/duct physical parameters at the sample site. Include the diameter for round stacks and the width and length for rectangular stacks. Consider the 'length' to be the dimension into the stack/duct and the 'width' to be the dimension along the stack/duct (dimension measurement holes are drilled into). Also indicate the stack or duct material of construction and the gauge or thickness.</p> <p>Note: These dimensions must be accurate. They will be used to purchase the sample probe.</p>
<b>Step 2 Expected velocity range</b>	Record the low, average, and high velocities from the last 3 years. Adjust these numbers if you expect changes to occur in the ventilation system (i.e., use design values if the system is currently undergoing modifications/construction).

## ANSI Sample Probe, continued

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### Step 3 Exhaust stack/duct reynolds number

Calculate the exhaust effluent's Reynolds number. If the flow is laminar, special considerations must be addressed when you decide where in the exhaust stack cross-section to place a single-point isokinetic probe.

$$Re = \frac{\rho V d}{\mu}$$

where:

- Re is the Reynolds Number (dimensionless)
- $\rho$  is the effluent density
- V is effluent velocity (average)
- d is cross-section diameter
- $\mu$  is effluent viscosity

Accounting for elevation, use

$$Re = (7.49)(V)(d)$$

where:

- V is the average velocity in ft/min.
- d is the cross-sectional diameter in inches.

Note: This is a rough approximation, but it is accurate enough to determine how close the flow is to the laminar region.

---

### Step 4 Sample flow rate

Record the sample flow rate.

## ANSI Sample Probe, continued

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**Step 5**  
**Number of sample nozzles**

Record the number of sample nozzles to be used on the ANSI probe.  
Document how the number was selected.

From ANSI N13.1 - 1969, Appendix A:

Circular Stacks and Ducts:

<u>Duct Diameter (inches)</u>	<u>Minimum Number of Points</u>
2 - 6	1
8 - 12	2
14 - 18	3
20 - 28	4
30 - 48	5
50 and larger	6

Rectangular Stacks and Ducts:

<u>Duct Area (sq ft)</u>	<u>Suggested Number of Points</u>
less than 0.5	1
1 - 2	4
2 - 25	6 - 12
> 25	20

---

**Step 6**  
**Nozzle size**

Indicate if isokinetic sampling is required. Calculate the required nozzle diameter for isokinetic or anisokinetic sampling. Also annotate the sample probe tube diameter.

Tritium and gas probes must be constructed of 3/8-inch outside diameter (OD) tubing with a wall thickness of 0.070 inches.

## ANSI Sample Probe, continued

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### Step 7 Probe specifications

Specify the sample probe material. Also indicate the nozzle spacing.

Tritium and gas probes must be constructed from 316 stainless steel tubing. Gas probes may need to be coated for reactive gases (e.g., with Teflon for iodine). The radius of bend of the probe tip must be 90 degrees and equal to or greater than 5 times the inner diameter of the probe ( $R \geq 5D$ ).

For laminar flow ( $Re \leq 2100$ ) in circular ducts the flow profile is a parabolic distribution of velocities. The maximum velocity occurs on the duct axis, and the average velocity occurs at about 7/10 of the radial distance from the axis of the duct to the wall. This average velocity is about 1/2 the centerline flow. If using a single-point isokinetic probe, locate it at the average velocity location.

---

### Step 8 Mounting flanges

Record the probe/stack mounting flange assembly drawing number. If the assembly is commercially available, record the manufacturer's part number.

The probe must be removable from the sample line and from the stack for inspection. Use compression fittings to attach the sample line to the probe. An additional mounting plate may be required for thin walled stacks or ductwork.

---

### Step 9 Probe

Record the probe manufacturer, model number, and serial number. This information must be stamped or etched onto the sample probe.

---

### Step 10 Probe installed

Record the date that the probe was installed and connected to the sampling system.

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### Step 11 Probe collection efficiency

Document any information from the manufacturer or from in-house testing concerning the sample probe collection efficiency.

## D.5 Single-Point Shrouded Sample Probe

<b>Form</b>	Document your work on form ESH-17-121-16.
<b>Applicability</b>	If you will use a single-point shrouded sample probe from Section D.1, complete Section D.5.
<b>Step 1 Exhaust stack/duct parameters</b>	<p>Record the exhaust stack/duct physical parameters. Include the diameter for round stacks and the width and length for rectangular stacks. Consider the 'length' to be the depth into the stack. Also indicate the stack or duct construction material and the gauge or thickness.</p> <p>Note: Use of the shrouded probe is limited to pipes and ducts with an internal diameter of <math>\geq 3</math> inches.</p>
<b>Step 2 Expected velocity range</b>	Record the low, average, and high velocities from the last 3 years. Adjust these numbers if you expect changes to occur in the ventilation system (i.e., use design values if the system is currently undergoing modifications/construction).
<b>Step 3 Sample flow rate</b>	<p>Record the sample flow rate.</p> <p>The sampling flow rate must be maintained at <math>\pm 25\%</math> of design specifications over the range of anticipated conditions.</p>
<b>Step 4 Probe specifications</b>	Specify the shrouded probe material.
<b>Step 5 Particle size range</b>	<p>Indicate the expected particle size range.</p> <p>"For situations or instances where the user of a shrouded probe expects that a facility's stack aerosol may contain a significant contribution of particles greater than <math>15\mu\text{m}</math> in size, laboratory evaluation of the probe's performance above <math>15\mu\text{m}</math> is expected." EPA June 15, 1995 letter.</p>

## Single-Point Shrouded Sample Probe, continued

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**Step 6  
Probe** Record the probe manufacturer, model number, and serial number. This information must be stamped or etched onto the sample probe. Also record the probe tube diameter.

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**Step 7  
Probe  
performance** Record the transmission ratio of the shrouded probe for the expected velocity range and sample flow rate.

The transmission ratio of the probe must be between 0.80 and 1.3 for 10  $\mu\text{m}$  AED aerosol particles. The transmission ratio is defined as the ratio of the particulate concentration delivered by the probe at the entrance of the sample transport line to the free stream particulate concentration.

---

**Step 8  
Probe frontal  
area** Calculate the probe frontal area. Use the probe frontal area to calculate the ratio of the probe frontal area to the stack or duct area.

$$A_p = \pi \left( \frac{d_p}{2} \right)^2$$

where

- $A_p$  is the probe (with shroud) frontal area in inches
- $d_p$  is the probe shroud external diameter in inches

$$R = (A_p/A_s) \times 100\%$$

where

- $A_p$  is the probe frontal area in inches
- $A_s$  is the stack or duct area in inches

The probe cannot be used if the frontal area is greater than 15% of the total stack area.



## Single-Point Shrouded Sample Probe, continued

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### Step 9 Mounting flanges

Record the probe/stack mounting flange assembly drawing number. If the assembly is commercially available, then record the manufacturer's part number.

The probe must be removable from the sample line and from the stack for inspection. Use compression fittings to attach the sample line to the probe. An additional mounting plate may be required for thin walled stacks or ductwork.

---

### Step 10 date probe installed

Indicate the date that the probe was installed and connected to the sampling system.

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### Step 11 Probe collection efficiency

Document any information from the manufacturer, from Texas A&M University, or from in-house testing, concerning the sample probe collection efficiency.

“The specifications for each shrouded probe must be fully documented, starting with the initial design requirements, manufacturing, and testing, and installation at the point of use. ... The documentation package must provide all information necessary to identify the original requester and the probe manufacturer, to address all design requirements, manufacturing, and testing. The testing criteria for each new probe must be  $\pm 7\%$  of mean value (of the transmission ratio) between the wind tunnel test results and model calculations for the nominal operating conditions with 10  $\mu\text{m}$  AED particles.” EPA Letter Dated November 21, 1994.

## E. Transport Line

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**Background** The sample transport line is the means to get the sample from the probe exit to the sample collector or real time monitor. It includes all tubes, pipes, and fittings from the probe exit to the sample collector or real time monitor inlet. While losses in a tritium or gas sample line do not normally impair the overall accuracy of the sample as in a particulate sample line, several considerations must be addressed to ensure that an adequate sample is collected.

Many factors effect particulate sample losses in transport tubing. Particles can be deposited on the internal walls of transport systems primarily by gravitational settling, turbulent diffusion, inertial impaction and Brownian diffusion. The influence that these deposition mechanisms have on sample loss depends, to a large extent, on the size and density of the sampled particles. Gravitational settling is dominant for larger particles ( $\geq 1 \mu\text{m AED}$ ), especially in horizontal runs. Turbulent diffusion's effect increases with flow rate and particle size but decrease with tube size. Brownian diffusion is dominant for smaller particles ( $< 0.1 \mu\text{m AED}$ ).

To assist in the design of an optimum sample transport line, complete Section E.1. Section E.1.A and E.1.B are used as input sheets for DEPOSITION to calculate both the optimum sample tube diameter and the total particulate penetration.

## E.1 Transport Line Design

---

**Form** Document your work on form ESH-17-121-17.

---

**Applicability** Complete Section E.1 to design the sample transport line. This section applies to particulates, tritium and gases.

---

**Step 1** Indicate what material to use for the sample transport line.

**Transport line material**

The sample transport line and related components should normally be constructed of 316 stainless steel with an internal surface roughness of less than 63  $\mu\text{in}$ . The decision to use stainless steel must consider corrosion caused by contact between dissimilar metals and chemical reactions with the effluent.

A short (less than 1-foot) section of flexible tubing may be used to provide an easy connection between the stainless steel sample transport line and the sample collector and/or real time monitor. Ensure that the internal diameter of the flexible tubing is greater than or equal to the internal diameter of the stainless steel sample transport line. Use natural rubber, neoprene, or vinyl for this tubing, unless these materials could react chemically with the effluent. Use polyvinyl chloride (PVC) or Teflon flexible tubing only for iodine effluents. Do not allow sharp bends in the flexible tubing.

---

**Step 2** Record the sample flow rate.

**Flow rate**

1 cfm = 28.32 lpm

## Transport Line Design, continued

**Step 3  
Particulate  
sample line  
optimization**

Calculate the optimum sample line diameter for particulates using the DEPOSITION software code. Also calculate the theoretical sample loss in the system.

- a) Indicate if the effluent gas mixture is air or some other gaseous mixture. If the mixture is not air, DEPOSITION cannot be used unless adjustments are made for the given mixture.
- b) Record the average temperature range expected in the exhaust stack or duct. If the expected temperature range is 0 - 50 °C (0 - 122 °F), use DEPOSITION Version 2.01. Otherwise, use Version 2.02.
- c) Complete Section E1A to determine the optimum sample tube diameter. Record the DEPOSITION results. Since the optimum diameter may be a range of values, select the actual diameter to use. Consider 'standard tubing sizes' when making this selection.
- d) Complete Section E1B to calculate the theoretical sample loss (percent penetration) in the system for 10 µm particles. Record the results.

“For single-point sampling with a shrouded probe, the overall performance of the system, from the sampling probe to the sample collection medium, must be shown to be  $\geq 50\%$  for 10 µm AED particles at the nominal sampling flow rate and free stream velocity.” EPA Letter Dated November 21, 1994.

To minimize particle losses in the sample system, consider the following:

- Minimize the length of tubing between the probe and the sample collector and/or real time monitor. Mount filter housings directly to the exit of the probe, or as close to the probe exit as possible. If a sample transport line between the probe and the sample collector and/or real time monitor is required, use vertical runs if possible rather than horizontal runs.
- Bends in the sample transport line can significantly increase sample loss in the line. Minimize the number and degree of bends. The radius of all bends must be greater than or equal to five times the internal diameter of the sample transport line.
- Connections can also lead to increased sample loss. Connections are required between the probe exit and the sample transport line, between the sample transport line and the collector and/or real time monitor, and between the sample transport line and a flow splitter, if installed. Design these connections to minimize their impact on flow through the sample transport line. The interior transition from component to component and the interior of the connection must be smooth and designed to minimize particulate losses.

## Transport Line Design, continued

### Step 4 Gas and tritium sample line

Record the sample line size for gases and tritium. Indicate if a fresh air line is required. Use 3/8-inch OD tubing with a 0.070-inch wall thickness (ID = 0.235 inch) as the standard size for gas and tritium sample line.

To minimize sample losses in the system, consider the following:

- Minimize the length of piping between the probe and monitor. Slope the sample line connected to the monitor by 5 degrees to prevent condensation entry. Provide a drain valve at the bottom of the sloped line for condensation removal.
- Bends in the transport line are not expected to significantly increase sample loss. However, minimize the number and degree of bends. The radius of all bends must be greater than or equal to 5 times the internal diameter of the transport line.
- Connect all hard line connections with compression fittings (e.g., Swagelock). Connect all soft line connections, such as flexible connections, with either stainless steel hose clamps or compression fittings. Allow for removal of all sampling line, fresh-air line, and return line sections for inspection, cleaning and replacement.

#### Tritium system fresh-air lines

- Determine if a fresh air line to an external air supply is required by consulting with ESH-4 RIC. Ideally, outside air should be used for a fresh air supply, but in some cases, practical considerations may indicate an inside air supply.
- The background contamination of a fresh-air supply should be as low as possible. If the background is unacceptably high for the outside air, use an inside air supply.
- The EL700 bubbler and the 224GB/U24 femto-Tech monitor must have separate, independent stainless-steel fresh-air lines. Isolate these lines with a valve assembly while the monitoring instruments are sampling the effluent.
- Construct fresh-air lines from 1/2-inch OD 316 stainless-steel tubing with a wall thickness of 0.070-inch. Reduce the tubing size as needed to attach fresh-air lines to the fresh-air port of the EL700 bubbler. Provide a three-way valve assembly for installation of the 224GB/U24 femto-Tech monitor. This valve will be located in the sample line upstream from the monitor's ion chamber and will be operationally accessible. Reduce the size of the fresh-air lines as needed to attach to the three-way valve.

## Transport Line Design, continued

### Gas and tritium sample line continued

- Slope the fresh-air lines by 5 degrees to prevent condensation entry into the instrument.
- Provide a drain valve at the bottom of the sloped line for condensation removal.

### Step 5 System response calculations

Indicate if sample line is for a real time monitor. If yes, record the total length of the sample transport line. Determine the system response time and indicate if the response time is acceptable.

Calculate the transport time as follows:

$$t = \frac{60\pi \left[ \frac{d}{24} \right]^2 l}{Q}$$

where:

- t = response time (seconds)
- d = inside tube diameter (inches)
- l = length of pipe (feet)
- Q = volumetric flow rate of gas through line (cfm)

### Tritium Systems

- Use 20 seconds as the maximum acceptable transport time for the 224GB/U24 femto-Tech monitor. In cases of unacceptable transport times caused by (1) distance between the probe and the sampler, and/or (2) sampler flow rate (10 - 20 L/min for the 224GB/U24 femto-Tech), make appropriate changes to the standard-diameter tubing.

### Step 6 Flow Splitter

Indicate if a flow splitter is used. If yes, record the drawing number.

In some cases, a single probe will supply multiple sample collectors and/or real time monitors. Use a flow splitter that limits the loss of 10 µm AED particles to less than 10%.

## Transport Line Design, continued

---

### Step 7 Heat trace

Indicate if heat tracing is required.

- Heat tracing is required for all transport lines that may be subjected to temperatures below 20° C.
  - Maintain the transport line at 20° C or higher. If, because of unusual operations, the effluent is hot and/or humid, establish a minimum temperature to prevent the sample from reaching its dew point.
  - Place the heat tracing on an uninterruptable power supply (UPS) or generator if the sampling system is on a UPS or generator.
  - Provide a visual method (e.g., an indicator light) to ensure that the heat trace element is operational.
- 

### Step 8 Return line

Indicate if a return line is required. If yes, record the size.

Installation of a return line is strongly recommended.

Tritium:

- Use separate lines to return the sampled air from the EL700 bubbler and the femto-Tech monitor. Ideally these lines will return air to the stack or duct downstream from the sample probe assembly. An economically feasible return, such as into a nearby duct or glove box, is acceptable.
  - Construct the return line with 1/2-inch OD 316 stainless steel tubing with a wall thickness of 0.070 inch. Reduce the size as needed to attach return lines to the exhaust port of the EL700 bubbler or to the pump assembly of the 224GB/U24 femto-Tech monitor.
  - Slope the return air line by 5 degrees to prevent condensation entry.
  - Provide a drain valve at the bottom of the sloped line for condensation removal.
- 

### Step 9 Comments

Provide any comments. Indicate if none.



## E.1.A Optimum Diameter Worksheet

<b>Form</b>	Document your work on form ESH-17-121-18.
<b>Applicability</b>	Complete Section E.1.A to calculate the optimum tube diameter of an aerosol transport system. The optimum tube diameter is calculated for an isokinetic probe with the penetration through the probe set to unity.
<b>Step 1 Transport system data</b>	<p>Record the transport system information to input into DEPOSITION. Include the flow rate, number of components, particle density, and the free stream velocity.</p> <p>Include the probe in the number of components space.</p> <p>Use the density of water (1 gm/cm<sup>3</sup>).</p>
<b>Step 2 Component information</b>	Record the component information. There are two types of components to select -- tube and elbow. In the columns labeled 1 - 2, record the information appropriate for the selected component.
<b>Step 3 Particle size distribution</b>	<p>Indicate if the calculations will be performed using monodisperse or polydisperse aerosols.</p> <p>If monodisperse is selected, record the AED of the aerosol. The EPA approved alternative method only requires a 10 µm AED monodisperse calculation.</p> <p>If polydisperse is selected, indicate if a user defined discrete distribution or a log-normal distribution will be used. Record the mean diameter and the geometric standard deviation.</p>

## E.1.B Total Penetration Worksheet

<b>Form</b>	Document your work on form ESH-17-121-19.
<b>Applicability</b>	Complete Section E.1.B to calculate the total penetration through the aerosol transport system and the penetration through each component.
<b>Step 1 Transport system data</b>	<p>Record the transport system information to input into DEPOSITION. Include the flow rate, tube diameter, number of components, and particle density.</p> <p>Include the probe in the number of components space.</p> <p>Use the density of water (1 gm/cm<sup>3</sup>).</p>
<b>Step 2 Component information</b>	Record the component information. There are three types of components to select -- probe, tube, and elbow. In the columns labeled 1 - 4, record the information appropriate for the selected component.
<b>Step 3 Particle size distribution</b>	<p>Indicate if the calculations will be performed using monodisperse or polydisperse aerosols.</p> <p>If monodisperse is selected, record the AED of the aerosol. The EPA approved alternative method only requires a 10 µm AED monodisperse calculation.</p> <p>If polydisperse is selected, indicate if a user defined discrete distribution or a log-normal distribution will be used. Record the mean diameter and the geometric standard deviation.</p>

## F. Vacuum System

<b>Background</b>	The vacuum system is comprised of the vacuum pump, motor, flow controller, flow rate indicator, weather house, cooling fan, and associated equipment. The system can also include flow totalizers, flow alarms, power failure sensors, and backup power systems.
<b>Form</b>	Record your work on form ESH-17-121-20.
<b>Applicability</b>	Complete Section F to specify vacuum system components.
<b>Step 1 System</b>	Indicate if the vacuum system supports sample collection or real-time monitoring. Record the sampler or monitor supported.
<b>Step 2 Location description</b>	Describe the sample system location. Provide enough detail so that someone who is not familiar with the sampling system can locate the system.
<b>Step 3 Pump</b>	<p>Indicate if the sampling system vacuum pump is the house vacuum system, a stand-alone vacuum pump, or an internal instrument vacuum pump. Record the vacuum pump manufacturer and model number</p> <p>If a stand-alone vacuum pump is used, install either Sutorbilt “F” series or Gast 23 series. JCI installs and maintains these vacuum pumps for ESH-17 (JCI PMI 40-25-002).</p> <p>Tritium:</p> <ul style="list-style-type: none"><li>• The EL700 bubbler contains an internal vacuum pump. The 224GB/U24 femto-Tech does not.</li></ul>
<b>Step 4 pump maintained by</b>	Indicate who maintains the sample vacuum pump.

## Vacuum System, continued

---

**Step 5**  
**Flow rate**  
**indicator**

Record the sample flow rate indicator's manufacturer, model number, and flow range. Indicate if a flow totalizer is installed and or if the sample flow is alarmed.

- Control the sample flow rate by using either a control valve, a critical orifice, or a critical flow venturi. Other methods may be used if they can provide a stable sample flow rate.
- Use Dwyer rotometers (or approved equal) to indicate sample flow rate. Consider installing a flow meter with flow totalizer.
- For CAM's and instruments with built-in flow indicators, use the built-in indicator to indicate sample flow rate.
- When a central monitoring location exists, consider indicating sample flow rate at the remote location. This may be required by nuclear facility TSRs.
- Consider using low-sample flow alarms when feasible. Low-sample flow alarms should be visible and audible. They should enunciate at all locations where the sample flow is indicated.

Tritium:

- An indication of the sample flow must be available locally at the sampling station (pump or monitor). Indication of sample flow at remote locations should be considered if there is a central monitoring location. The EL700 bubbler provides sample flow indication internally. The 224GB/U24 femto-Tech does not have this capability.
- Both the EL700 bubbler and the 224GB/U24 femto-Tech monitor have a low-sample flow alarm. The EL700 bubbler has an internal alarm. The femto-Tech monitor alarm system will have local and remote alarms, both audible and visual. The operating groups will determine the location of the remote alarms. Proper standard operating procedures (SOP's) must be in place for the response to remote alarms.

## G. Installation Requirements and System Acceptance

---

**Background**     Install the sampling and/or monitoring systems using skilled craftsmen. Section G.1 provides basic installation requirements for installing sampling systems. Section G.2 provides a checklist, which must be completed before accepting a system for compliance sampling.

## G.1 Installation Requirements

<b>Form</b>	None
<b>Applicability</b>	Complete Section G.1 requirements for all new sampling system installations and upgrades.
<b>Probe</b>	Mount the sample probe aligned parallel to the flow at the sampling location. The probe must have the manufacturer, serial number, and flow rate permanently stamped or etched on the surface.
<b>Sampler or monitor</b>	Instal the sampler or monitor in accordance with the manufacturer's recommendations.
<b>Transport lines</b>	<p>Provide adequate support for the sample transport line to ensure stability and security.</p> <ul style="list-style-type: none"><li>• Determine the spacing of supports based on pipe size or schedule.</li><li>• Consider extra support or other protection for a sample transport line that may be subject to damage because of its position relative to traffic or operations.</li></ul> <p>Heat trace all sample lines when required as specified previously in this procedure.</p> <p>Slope the sample transport line as specified previously.</p>
<b>Vacuum System</b>	Provide sufficient vacuum to draw the required flow rate. The vacuum pump must have, as a minimum, a means to control the flow and a flow rate indicator.

## Installation Requirements, continued

---

- Electrical**      Hard-wire all sources of electrical power. For example, a sample pump or CAM must be plugged into a hard-wired outlet, not an extension cord.
- In facilities where the exhaust system is supported by an uninterruptable power supply or generator, support the sampling and/or monitoring system with the same or equivalent back-up power source. This requirement includes all heat tracing used on the sampling line.
  - Provide weather houses for all electrical equipment that is located outdoors. Consider the use of a weather house for additional equipment security at indoor locations.
- 

- Return line**      Provide adequate support for the return line to ensure stability and security.
- Determine the spacing of supports based on pipe size or schedule.
  - Consider extra support or other protection for a sample transport line that may be subject to damage because of its position relative to traffic or operations.
- 

Slope the return line and provide drain valves as required.

---

- Labels**      Label exhaust stack sampling/monitoring systems. Include the following information on the labels:
- Velocity Measurement Location
  - Aerosol/Gas Measurement Location
  - Sample Probe
  - Stand-Alone Vacuum Pump
  - Flow Rate Indicator

## Installation Requirements, continued

---

**As-built drawings**

Prepare sampling/monitoring system as-built drawings. As a minimum, include:

- The ventilation system from the pollution control device to the exhaust outlet. Dimension to within  $\pm 1/4$  inch.
- All flow disturbances within 10 duct diameters on either side of the sampling site.
- For the sampling system, include the sample line, return line, probe, monitoring/sampling instruments, flow rate indicator, and vacuum pump.
- For the exhaust stack or vent, include exit orientation, height and elevation, dimensions, and exit area.

---

**Total flow measurement systems**

Although not a requirement, continuous total stack/duct flow measurement systems may be recommended for certain high inventory facilities.

- Continuous total stack flow measurement systems used for reporting to EPA must be calibrated annually.



## G.2 System Acceptance

---

**Form** Document your work on form ESH-17-121-21.

---

**Applicability** Complete Section G.2 for all new installations.

---

**Step 1  
Probe** Is the probe:

- mounted in the specified location?
- correctly aligned?
- etched or engraved with the manufacturer, serial number, and range?

---

**Step 2  
Sampler or  
monitor** Is the sampler or monitor:

- correct as specified from Section A.3?
- installed according to the manufacturer's recommendations?

---

**Step 3  
Transport  
lines** Are the transport lines:

- made of the specified material?
- the correct size?
- made with the correct radius bends?
- vacuum tested?

---

**Step 4  
Vacuum  
system** Is the vacuum system:

- connected and operating properly?
- set at the correct sample flow rate?
- calibrated?

---

**Step 5  
Electrical** Is the electrical system:

- hard wired?
- protected from the weather?
- lightning protected?
- connected to UPS or generators if required?

## System Acceptance, continued

---

### Step 6 Return lines

Is the return line:

- the correct material?
  - adequately supported?
  - sloped toward the stack or duct?
- 

### Step 7 Labels

Are the labels installed? Do they include:

- Velocity Measurement Location?
  - Aerosol/Gas Measurement Location?
  - Sample Probe?
  - Vacuum Pump?
  - Flow Rate Indicator?
- 

### Step 8 Performance tests

Performance tests:

Particulate -- Challenge the aerosol transport efficiency of the entire sample train from the probe inlet to the collector and/or continuous air monitor (CAM).

For single-point sampling using a shrouded probe, the system should collect and transport at least 50% of the particles having an aerodynamic equivalent diameter (AED) of 10 $\mu$ m.

Tritium -- Direct ESH-4 RIC to perform a tritium system test (calibration) to demonstrate the sample line transport and overall collection efficiency.

## H. Documentation

---

**Form**

ESH-17-121-22, Sampling/Monitoring Documentation Checklist  
ESH-17-121-23, Continuation Page  
ESH-17-121-24, Variance Request

---

**Applicability**

Complete Section H to finalize the documentation for the stack sampling and/or monitoring system installation. Attach all completed forms using ESH-17-121-22 as the cover page.

- Sign Form ESH-17-121-22 indicating that the installation was completed in accordance with ESH-17-121. Indicate on the form which forms were completed and attached.
- Use Form ESH-17-121-23 as the continuation page for each form requiring additional space. Indicate at the top of the form which form is being continued and the total number of pages used.
- Complete Form ESH-17-121-24 to document any variations to this procedure. This form must be signed by the ESH-17 group leader or deputy group leader.

## I. Records Resulting From This Procedure

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### Records

The following records generated as a result of this procedure are to be submitted to the records coordinator:

- Completed forms ESH-17-01 through ESH-17-24

[Click here to record “self-study” training to this procedure.](#)

Air Quality Group  
**Process**

Form ESH-17-121-01

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. Description of the Process:**

SAMPLE

**2. Contaminants Generated By Process:**

- |                                      |   |
|--------------------------------------|---|
| <input type="checkbox"/> Particulate | <input type="checkbox"/> AED $\leq 3 \mu\text{m}$                         |
|                                      | <input type="checkbox"/> $3 \mu\text{m} < \text{AED} \leq 15 \mu\text{m}$ |
|                                      | <input type="checkbox"/> $15 \mu\text{m} < \text{AED}$                    |
| <input type="checkbox"/> Gases       | <input type="checkbox"/> Condensable                                      |
|                                      | <input type="checkbox"/> Non-Condensable                                  |
|                                      | <input type="checkbox"/> Reactive   |
| <input type="checkbox"/> Corrosives  | _____   |

**3. Exhaust Air Parameters:**

Expected Temperature Range: \_\_\_\_\_ (°C)

Expected Humidity Range: \_\_\_\_\_ (%RH)

Continuation Page(s) Attached? ☐ Yes ☐ No

\_\_\_\_\_  
Name

\_\_\_\_\_  
Z-Number

\_\_\_\_\_  
Signature

\_\_\_\_/\_\_\_\_/\_\_\_\_  
Date



Air Quality Group  
**Sampling/Monitoring Requirements**

Form ESH-17-121-02

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. PEDE:**

PEDE: \_\_\_\_\_ ESH-17-102 Review Form Dated \_\_\_\_/\_\_\_\_/\_\_\_\_

Sampling Required? ☐ Yes (PEDE  $\geq$  0.10 mrem/yr) ☐ No

Monitoring Required? ☐ Yes (Provide Justification) ☐ No

Justification:

SAMPLE

**2. Sampling Requirements:**

☐ Particulates

☐ Tritium

☐ Gases

☐ Iodine

☐ Argon, Krypton, and Xenon

☐ Oxygen, Carbon, Nitrogen, and Radon

☐ Volatiles

**3. Monitoring Requirements:**

☐ Particulates

☐ Tritium

☐ Gases

☐ Alpha

☐ Beta

☐ Gamma

☐ Alpha

☐ Beta

☐ Gamma

Continuation Page(s) Attached? ☐ Yes ☐ No

\_\_\_\_\_  
Name

\_\_\_\_\_  
Z-Number

\_\_\_\_\_  
Signature

\_\_\_\_/\_\_\_\_/\_\_\_\_  
Date





Air Quality Group  
**Sampler/Monitor**

Form ESH-17-121-03

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. Sampling Methods:** ☐ Not Required

SAMPLE

**2. Monitoring Methods:** ☐ Not Required

Continuation Page(s) Attached? ☐ Yes ☐ No

\_\_\_\_\_  
Name Z-Number Signature Date \_\_\_\_/\_\_\_\_/\_\_\_\_



Air Quality Group  
**Ventilation System**

Page 1, Form ESH-17-121-04

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. As-Built Drawings:**

Attach Drawing List From The ESH-17 As-Built Drawing Database

**2. Pollution Control Devices:**

Are Pollution Control Devices Installed? ☐ Yes ☐ No Attach Form(s) ESH-17-121-05

**3. Fan(s):** Attach Form(s) ESH-17-121-06

Number of Fan Exhausts: \_\_\_\_\_

List: FE- \_\_\_\_\_ FE- \_\_\_\_\_ FE- \_\_\_\_\_ FE- \_\_\_\_\_

Other \_\_\_\_\_

**4. Fan Configuration(s):**

CF-1: \_\_\_\_\_

CF-2: \_\_\_\_\_

CF-3: \_\_\_\_\_

**5. Exhaust Stack:** Attach Form ESH-17-121-07

☐ Vertical Stack ☐ Horizontal Vent ☐ Other (specify) \_\_\_\_\_

**6. General Description of Ventilation System:**

Air Quality Group  
**Ventilation System**

Page 2, Form ESH-17-121-04

**7. Detailed Description of Ventilated Areas:**

SAMPLE

Continuation Page(s) Attached? ☐ Yes ☐ No

\_\_\_\_\_  
Name

\_\_\_\_\_  
Z-Number

\_\_\_\_\_  
Signature

\_\_\_\_/\_\_\_\_/\_\_\_\_  
Date

Air Quality Group  
**Pollution Control Devices**

Form ESH-17-121-05

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

1. Device Number: \_\_\_\_\_

2. Fan Exhaust: FE- \_\_\_\_\_ Others: \_\_\_\_\_

3. Pollution Control Method(s):

☐ Filtration

☐ ASHRAE 52

☐ HEPA

☐ 1 -Stage

☐ 2 -Stage

☐ 3 -Stage

☐ -Stage

☐ Other \_\_\_\_\_

☐ Other \_\_\_\_\_

4. Test Frequency:

☐ Annual

☐ Semi-Annual

☐ Quarterly

☐ None

☐ Other \_\_\_\_\_

5. Test Results (Last Three):

Date: \_\_\_\_/\_\_\_\_/\_\_\_\_

☐ Pass

☐ Fail Standard: \_\_\_\_\_

Date: \_\_\_\_/\_\_\_\_/\_\_\_\_

☐ Pass

☐ Fail Standard: \_\_\_\_\_

Date: \_\_\_\_/\_\_\_\_/\_\_\_\_

☐ Pass

☐ Fail Standard: \_\_\_\_\_

6. Description: ☐ None

Continuation Page(s) Attached? ☐ Yes ☐ No

Name \_\_\_\_\_

Z-Number \_\_\_\_\_

Signature \_\_\_\_\_

Date \_\_\_\_/\_\_\_\_/\_\_\_\_



Air Quality Group  
**Fan Exhaust**

Form ESH-17-121-06

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. Fan Exhaust:** FE- \_\_\_\_\_

**2. Fan:**

Fan Type: \_\_\_\_\_

Manufacturer: \_\_\_\_\_

Model: \_\_\_\_\_ SN: \_\_\_\_\_

Dampers: ☐ Inlet ☐ Outlet ☐ Unknown

Turning Vanes: ☐ Yes ☐ No ☐ Unknown

Fan Outlet Exhausts: ☐ Over ☐ Under ☐ Vertical

**3. Motor:**

Motor Type: \_\_\_\_\_

Manufacturer: \_\_\_\_\_

HP: \_\_\_\_\_ Rating: \_\_\_\_\_ RPM: \_\_\_\_\_

Speed: ☐ 1-Speed ☐ 2-Speed ☐ Variable Speed

**4. Comments:** ☐ None

Continuation Page(s) Attached? ☐ Yes ☐ No

\_\_\_\_\_  
Name Z-Number Signature Date \_\_\_\_/\_\_\_\_/\_\_\_\_





Air Quality Group  
**Exhaust Stack Height, Elevations and Exit Parameters**

Form ESH-17-121-07

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. Reference Grade Elevation (RG):**

Building Reference Grade Elevation: RG-1 \_\_\_\_\_ ft (a)

Building Reference Grade Elevation Source

☐ Engineering Drawing: Drawing Number \_\_\_\_\_

☐ Other \_\_\_\_\_

Description of Reference Grade Location:

**2. Intermediate Reference Height(s) (IR):**

Building Intermediate Reference Height(s) IR-1 \_\_\_\_\_ ft (b1)

IR-2 \_\_\_\_\_ ft (b2)

Description of Intermediate Reference Height(s):

**3. Exhaust Stack Height:**

Exhaust Stack Height From IR-\_\_\_\_\_: \_\_\_\_\_ ft (c)

Exhaust Stack Height Above Building Reference Grade: \_\_\_\_\_ ft \_\_\_\_\_ m  $d=(b_+c)$

**4. Exhaust Stack Exit Plane and Elevation:**

☐ Exhaust Stack (Vertical) ☐ Exhaust Vent (Horizontal)

☐ Exhaust Other Describe: \_\_\_\_\_

Exhaust Stack Exit Elevation: \_\_\_\_\_ ft (a + d)

**5. Exhaust Stack Exit Area:**

Dimensions: Diameter \_\_\_\_\_ ft or Rectangle \_\_\_\_\_ ft by \_\_\_\_\_ ft

Area: \_\_\_\_\_ ft<sup>2</sup> \_\_\_\_\_ m<sup>2</sup>

\_\_\_\_\_  
Name

\_\_\_\_\_  
Z-Number

\_\_\_\_\_  
Signature

\_\_\_\_/\_\_\_\_/\_\_\_\_  
Date



Air Quality Group  
**Site Selection**

Page 1, Form ESH-17-121-08

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. Describe Sampling Site:**

SAMPLE

**2. Measure Sampling/Monitoring Site Physical Dimensions:**

- ☐ Round Diameter: \_\_\_\_\_ inches
- ☐ Rectangular Width: \_\_\_\_\_ inches
- Length: \_\_\_\_\_ inches

**3. Calculate The Rectangular Equivalent Diameter:**

$$D_e = \frac{2LW}{(L + W)}$$

Equivalent Diameter: \_\_\_\_\_ inches

**4. Calculate The Sampling/Monitoring Site Cross-Sectional Area:**

Area: \_\_\_\_\_ (ft<sup>2</sup>)

Air Quality Group  
**Site Selection**

Page 2, Form ESH-17-121-08

**5. Measure The Distance From The Sampling Site To The Nearest Flow Disturbances:**

Nearest Upstream Disturbance: \_\_\_\_\_ inches

Nearest Downstream Disturbance: \_\_\_\_\_ inches

**6. Calculate The Duct Diameter Ratio From The Sampling Site To The Flow Disturbances:**

Upstream Disturbance: \_\_\_\_\_  $DD_{Up}$

Downstream Disturbance: \_\_\_\_\_  $DD_{Down}$

**7. Method 1 Traverse Requirements:**

☐  $DD_{Up} \geq 8$  and  $DD_{Down} \geq 2$  Then;

☐ Round Use 2 by 12 Measurement Traverse

☐ Rectangular Use 5 by 5 Measurement Traverse

Go To Step 8.

☐  $[2 \leq DD_{Up} < 8 \text{ and } DD_{Down} \geq 1/2]$  or  $[DD_{Up} \geq 2 \text{ and } 1/2 \leq DD_{Down} < 2]$  Then;

☐ Round Use 2 by 12 Measurement Traverse

☐ Rectangular Use 5 by 5 Measurement Traverse

Go To Step 8.

☐  $DD_{Up} < 2$  or  $DD_{Down} < 1/2$  Then;

☐ Round Use 2 by 20 Measurement Traverse

☐ Rectangular Use 7 by 6 Measurement Traverse

Go To Step 9.

**8. Perform Cyclonic Flow Analysis:** ☐ Step 9 Completed

Cyclonic Flow Conditions Acceptable?

☐ Yes Go To Step 10.  
(Attach Form ESH-17-121-09)

☐ No Stop, Sampling Site Is Unacceptable.

Air Quality Group  
**Site Selection**

Page 3, Form ESH-17-121-08

**9. Perform Alternative Cyclonic Flow Analysis:** ☐ Step 8 Completed

Cyclonic Flow Conditions Acceptable?

☐ Yes Go To Step 10.  
(Attach Form ESH-17-121-10)

☐ No Stop, Sampling Site Is Unacceptable.

**10. Acceptability of Sampling Site:**

☐ Sampling Site Is Acceptable IAW EPA Method 1 Requirements

**11. Comments:** ☐ None

SAMPLE

Continuation Page(s) Attached? ☐ Yes ☐ No

\_\_\_\_\_  
Name Z-Number Signature Date \_\_\_\_/\_\_\_\_/\_\_\_\_



Air Quality Group  
**Cyclonic Flow Analysis**

Form ESH-17-121-09

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. Measure The Average Cyclonic Flow Rotation Angle ( $\alpha$ ):**

Average Cyclonic Flow Rotation Angle ( $\alpha$ ): \_\_\_\_\_ degrees

Cyclonic Flow Report Dated: \_\_\_\_/\_\_\_\_/\_\_\_\_ (JCI MOI 41-30-009)

**2. Determine Acceptability of Sampling Site Based on Cyclonic Flow Conditions:**

<input type="checkbox"/>	Average Rotation Angle Is Less Than Or Equal To 20 Degrees.	Meets Method 1 Cyclonic Flow Criteria.
<input type="checkbox"/>	Average Rotation Angle Is Greater Than 20 Degrees.	Does Not Meet Method 1 Cyclonic Flow Criteria.

**3. Flow Conditioning:**

Is Flow Conditioning Installed? ☐ Yes (If yes, describe in detail)  
☐ No

SAMPLE

Continuation Page(s) Attached? ☐ Yes ☐ No

Sample Site Cyclonic Flow Conditions Are ☐ Acceptable ☐ Not Acceptable IAW EPA Method 1.

\_\_\_\_\_  
Name Z-Number Signature Date \_\_\_\_/\_\_\_\_/\_\_\_\_





Air Quality Group  
**Alternative Cyclonic Flow Analysis**

Form ESH-17-121-10

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. Sampling Site:**

Site Is Located Less Than 2 Stack or Duct Diameters Downstream or 1/2 Stack or Duct Diameters Upstream From A Flow Disturbance

☐ Yes Continue  
☐ No Stop

Duct Diameter Is Greater Than 24 inches.

☐ Yes Continue (Can Use Method 1 Section 2.5)  
☐ No Go To Step 2 and Select 'Other'

**2. Alternative Site Selection Procedure:**

☐ Method 1 Section 2.5 Go To Step 3  
☐ Other Go To Step 4

**3. Method 1 Section 2.5:**

Measurement Report Dated \_\_\_\_/\_\_\_\_/\_\_\_\_ (JCI MOI )

Average Resultant Angle ( $\bar{R}$ ): \_\_\_\_\_ (degree)

Standard Deviation ( $S_d$ ): \_\_\_\_\_ (degree)

☐ Acceptable  $\bar{R} \leq 20^\circ$   
 $S_d \leq 10^\circ$

☐ Unacceptable

**4. Other Cyclonic Flow Measurement Methods:**

Describe In Detail Selection Method & Approvals

Continuation Sheet(s) Attached? ☐ Yes ☐ No

Sample Site Cyclonic Flow Conditions Are ☐ Acceptable ☐ Not Acceptable IAW EPA Method 1.

\_\_\_\_\_  
Name Z-Number Signature Date \_\_\_\_/\_\_\_\_/\_\_\_\_



Air Quality Group  
**Flow Measurement Location**

Page 1, Form ESH-17-121-11

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. Description Of The Flow Measurement Location:**

SAMPLE

**2. Flow Measurement Location Physical Dimensions:**

☐ Round                      Diameter: \_\_\_\_\_ inches  
☐ Rectangular              Width: \_\_\_\_\_ inches  
   Length: \_\_\_\_\_ inches

**3. Flow Measurement Location Cross-Sectional Area:**

Area: \_\_\_\_\_ (ft<sup>2</sup>)

**4. Flow Measurement Location Elevation:**

Elevation: \_\_\_\_\_ (ft)

Air Quality Group  
**Flow Measurement Location**

Page 2, Form ESH-17-121-11

**5. Method 1 Traverse Requirements:**

- ☐  $DD_{Up} \geq 8$  and  $DD_{Down} \geq 2$  or  
☐  $[2 \leq DD_{Up} < 8$  and  $DD_{Down} \geq 1/2]$  or  $[DD_{Up} \geq 2$  and  $1/2 \leq DD_{Down} < 2]$  Then;
- ☐ Round      Use 2 by 12 Measurement Traverse
- ☐ Rectangular      Use 5 by 5 Measurement Traverse
- ☐  $DD_{Up} < 2$  or  $DD_{Down} < 1/2$  Then;
- ☐ Round      Use 2 by 20 Measurement Traverse
- ☐ Rectangular      Use 7 by 6 Measurement Traverse

**6. Spacing:**

Use JCI Procedure MOI 41-30-009 Appendices To Determine Traverse Spacing.

**7. Comments:**    ☐ None

SAMPLE

Continuation Page(s) Attached?    ☐ Yes    ☐ No

\_\_\_\_\_  
Name

\_\_\_\_\_  
Z-Number

\_\_\_\_\_  
Signature

\_\_\_\_/\_\_\_\_/\_\_\_\_  
Date

Air Quality Group  
**Sample Extraction Methodology Selection**

Page 1, Form ESH-17-121-12

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. Sample Site:** Sample Site Number: \_\_\_\_\_

Sample Site Acceptable From Section C? ☐ Yes Go To Step 2.  
☐ No Stop.

**2. Lateral Flow:**

Are There Any Low Momentum Lateral Flows Entering The Exhaust Stack/Duct?

☐ Yes

Is There A Potential That The Lateral Flow Discharge PEDE Could Exceed 1% of the Standard?

☐ Yes

Lateral Flow Must Be Mixed or New Site Selected.

☐ No

Go To Step 3.

☐ No

Go To Step 3.

**3. Tritium and Gaseous Radionuclides:** ☐ None

☐ Velocity Profile

Is The Coefficient of Variation  $\leq 20\%$  For The Inner 2/3 Area?

☐ Yes

Use A Single Point Gas Probe. Go To Step 8.

☐ No

Go To Step 6.

**4. Particulate Radionuclides:** ☐ None

a) ☐ Velocity Profile

Is The Coefficient of Variation  $\leq 20\%$  For The Inner 2/3 Area?

☐ Yes

Go To Step 4.b.

☐ No

Go To Step 6.

Air Quality Group  
**Sample Extraction Methodology Selection**

Page 2, Form ESH-17-121-12

**4. Particulate Radionuclides (cont):**

b) ☐ Gas Profile ☐ Not Performed. Complete Step 5.

1) Is The Coefficient of Variation  $\leq 20\%$  For The Inner 2/3 Area?

☐ Yes Go To Step 4.b.2.

☐ No Go To Step 6.

2) At Any Point, Is The Gas Concentration More Than 30% > The Mean Concentration Across The Cross-Section?

☐ Yes Go To Step 6.

☐ No Go To Step 4.c.

c) ☐ Aerosol Profile: ☐ Not Performed. Complete Step 5.

Is The Coefficient of Variation  $\leq 20\%$  For The Inner 2/3 Area?

☐ Yes Use A Single-Point Shrouded Probe. Go To Step 8.

☐ No Go To Step 6.

**5. Comments On Deviations:**

☐ None

Air Quality Group  
**Sample Extraction Methodology Selection**

Page 3, Form ESH-17-121-12

**6. Conservative Sample:**

☐ Not Used

Is A Location Available Which Can Provide A Conservative Sample?

☐ Yes

☐ Gas

Use A Single-Point Gas Sample Probe Placed In  
The Conservative Location. Go To Step 7.

☐ Particulate

Use A Single-Point Shrouded Probe Placed In The  
Conservative Location. Go To Step 7.

☐ No

☐ Gas

Use An ANSI-Type Sample Probe.  
Go To Step 8.

☐ Particulate

Use An ANSI-Type Isokinetic Sample Probe.  
Go To Step 8.

**7. Description of Conservative Sample Location and Selection Process:**

☐ Not Used

SAMPLE

**8. Sampling Rate:**

☐ Isokinetic

☐ Anisokinetic

**9. Comments on Representative Sample Collection:**

Continuation Page(s) Attached? ☐ Yes ☐ No

\_\_\_\_\_  
Name

\_\_\_\_\_  
Z-Number

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

/ /





Air Quality Group  
**Flow And Mixing Characteristics**

Form ESH-17-121-13

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. Method 2 Flow Rate Measurements:**

Method 2 Flow Measurement Date \_\_\_\_/\_\_\_\_/\_\_\_\_ (JCI MOI 41-30-009)

Avg Velocity \_\_\_\_\_ (fpm) \_\_\_\_\_ (mps)

Flow Rate: \_\_\_\_\_ (acfm) \_\_\_\_\_ (lpm)

Coefficient of Variation: \_\_\_\_\_ 100% of Area  
\_\_\_\_\_ Central 2/3 Area

**2. Gas Challenge:** ☐ Not Performed

Gas Challenge Measurement Date \_\_\_\_/\_\_\_\_/\_\_\_\_

Report Number \_\_\_\_\_ Dated \_\_\_\_/\_\_\_\_/\_\_\_\_

Coefficient of Variation: \_\_\_\_\_ Central 2/3 Area

At Any Point, Is The Gas Concentration More Than 30% Greater Than The  
Mean Concentration Across The Stack/Duct Cross-Section? ☐ Yes  
☐ No

**3. Aerosol Challenge:** ☐ Not Performed

Aerosol Challenge Measurement Date \_\_\_\_/\_\_\_\_/\_\_\_\_

Report Number \_\_\_\_\_ Dated \_\_\_\_/\_\_\_\_/\_\_\_\_

Particle Size: \_\_\_\_\_  $\mu\text{m}$

Coefficient of Variation: \_\_\_\_\_ Central 2/3 Area

**4. Comments:** ☐ None

Continuation Page(s) Attached? ☐ Yes ☐ No

\_\_\_\_\_  
Name Z-Number Signature Date \_\_\_\_/\_\_\_\_/\_\_\_\_



Air Quality Group  
**Engineering Studies**

Form ESH-17-121-14

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. Description & Results of Engineering Studies Performed on Ventilation System:**

SAMPLE

Continuation Page(s) Attached? ☐ Yes ☐ No

\_\_\_\_\_  
Name Z-Number Signature Date \_\_\_\_/\_\_\_\_/\_\_\_\_



Air Quality Group  
**ANSI Sample Probe**

Page 1, Form ESH-17-121-15

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. Exhaust Stack/Duct Parameters:**

☐ Round Diameter: \_\_\_\_\_ (in)

☐ Rectangular Width: \_\_\_\_\_ (in)

Length: \_\_\_\_\_ (in)

Stack/Duct Material: \_\_\_\_\_

Gauge or Thickness: \_\_\_\_\_

**2. Expected Velocity Range:**

Low: \_\_\_\_\_ (fpm) \_\_\_\_\_ (mps)

Avg: \_\_\_\_\_ (fpm) \_\_\_\_\_ (mps)

High: \_\_\_\_\_ (fpm) \_\_\_\_\_ (mps)

**3. Exhaust Stack/Duct Reynolds Number:**

Reynolds Number: \_\_\_\_\_

☐ Turbulent Flow  $Re > 2100$

☐ Laminar Flow  $Re \leq 2100$

**4. Sample Flow Rate:**

Sample Flow Rate: \_\_\_\_\_ (cfm) \_\_\_\_\_ (lpm)

**5. Number of Sample Nozzles:**

Number of Nozzles: \_\_\_\_\_

Determined From:

Air Quality Group  
**ANSI Sample Probe**

Page 2, Form ESH-17-121-15

**6. Nozzle Size:**

Flow Sampled: ☐ Isokinetic  
☐ Anisokinetic

Nozzle Size: \_\_\_\_\_

**7. Probe Specifications:**

Probe Material: ☐ 304 Stainless Steel  
☐ 316 Stainless Steel  
☐ Other \_\_\_\_\_

Nozzle Spacing: \_\_\_\_\_

Probe Tube Diameter: \_\_\_\_\_

**8. Mounting Flanges:**

Drawing Number: \_\_\_\_\_

**9. Probe:**

Manufacturer: \_\_\_\_\_

Model Number: \_\_\_\_\_ Serial Number: \_\_\_\_\_

**10. Probe Installed:**

Date Probe Installed: \_\_\_\_/\_\_\_\_/\_\_\_\_

**11. Probe Collection Efficiency:** ☐ Not Available

Continuation Page(s) Attached? ☐ Yes ☐ No

\_\_\_\_\_  
Name Z-Number Signature Date \_\_\_\_/\_\_\_\_/\_\_\_\_

Air Quality Group  
**Single-Point Shrouded Sample Probe**

Page 1, Form ESH-17-121-16

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. Exhaust Stack/Duct Parameters:**

☐ Round Diameter: \_\_\_\_\_ (in)

☐ Rectangular Width: \_\_\_\_\_ (in)

Length: \_\_\_\_\_ (in)

Stack/Duct Material: \_\_\_\_\_

Gauge or Thickness: \_\_\_\_\_

**2. Expected Velocity Range:**

Low: \_\_\_\_\_ (fpm) \_\_\_\_\_ (mps)

Avg: \_\_\_\_\_ (fpm) \_\_\_\_\_ (mps)

High: \_\_\_\_\_ (fpm) \_\_\_\_\_ (mps)

**3. Sample Flow Rate:**

Sample Flow Rate: \_\_\_\_\_ (cfm) \_\_\_\_\_ (lpm)

**4. Probe Specifications:**

Probe Material: ☐ 304 Stainless Steel  
☐ 316 Stainless Steel  
☐ Other \_\_\_\_\_

**5. Particle Size Range:**

Particle Size Expected: ☐  $\leq 15 \mu\text{m}$

☐  $> 15 \mu\text{m}$  Additional Testing Required

**6. Probe:**

Manufacturer: \_\_\_\_\_

Model Number: \_\_\_\_\_ Serial Number: \_\_\_\_\_

Probe Tube Diameter: \_\_\_\_\_ (in)

Air Quality Group  
**Single-Point Shrouded Sample Probe**

Page 2, Form ESH-17-121-16

**7. Probe Performance:**

Transmission Ratio: \_\_\_\_\_ for 10  $\mu$ m particles.

**8. Probe Frontal Area:**

Exhaust Stack/Duct Area ( $A_s$ ): \_\_\_\_\_ ( $\text{in}^2$ )

Probe External Diameter ( $d_p$ ): \_\_\_\_\_ (in)

Probe Frontal Area ( $A_p$ ):  $A_p = \pi \left( \frac{d_p}{2} \right)^2$  \_\_\_\_\_ ( $\text{in}^2$ )

Ratio ( $A_p/A_s$ ) x 100%: \_\_\_\_\_ %

☐ Acceptable

$A_p/A_s \leq 15\%$

☐ Not Acceptable

$A_p/A_s > 15\%$

**9. Mounting Flanges:**

Drawing Number: \_\_\_\_\_

**10. Date Installed:**

Date Probe Installed: \_\_\_\_/\_\_\_\_/\_\_\_\_

**11. Comments:** ☐ None

Continuation Page(s) Attached?

☐ Yes

☐ No

\_\_\_\_\_  
Name

\_\_\_\_\_  
Z-Number

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

/\_\_\_\_/\_\_\_\_



Air Quality Group  
**Transport Line Design**

Page 1, Form ESH-17-121-17

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. Transport Line Material:**

Material: ☐ 304 SS ☐ 316 SS ☐ Copper ☐ \_\_\_\_\_

**2. Flow Rate:**

Flow Rate (Q): \_\_\_\_\_ (cfm) \_\_\_\_\_ (lpm)

**3. Particulate Sample Line Optimization:** ☐ Not Required

a) Effluent Gas Mixture

☐ Air

☐ Other \_\_\_\_\_

Go To Step 3.b.

DEPOSITION Cannot Be Used

b) Average Temperature: \_\_\_\_\_

☐ Temperature (0 - 50 °C)

Use Version 2.01 or Newer

☐ Temperature (Outside Above Range)

Use Version 2.02 or Newer

c) Transport Line Optimization: (Complete Section E.1.A)

Optimum Tube Diameter: \_\_\_\_\_ (mm)

Use (d): \_\_\_\_\_ (in) \_\_\_\_\_ (mm)

d) Sample Loss Calculations: (Complete Section E.2.A)

Penetration: \_\_\_\_\_ % for 10 µm particles

☐ ANSI Probes

☐ Single-Point Shrouded Probes

☐ ≥ 50% Acceptable

☐ < 50% Not Acceptable

Air Quality Group  
**Transport Line Design**

Page 2, Form ESH-17-121-17

**4. Gas And Tritium Sample Line Size:** ☐ Not Required

Use (d): \_\_\_\_\_ (in) \_\_\_\_\_ (mm)

☐ Fresh Air Line Required

**5. System Response Calculations:**

Real Time Monitor?

☐ Yes, Complete Step 5

☐ No, Go to Step 6

Total Length of Sample Line (l): \_\_\_\_\_ (ft)

t = \_\_\_\_\_ (sec)

Response Time Acceptable?

☐ Yes

☐ No

**6. Flow Splitter:**

Is A Flow Splitter Used?

☐ Yes

☐ No

Drawing Number: \_\_\_\_\_

**7. Heat Trace:**

Install Heat Trace?

☐ Yes

☐ No

**8. Return Line:**

Install Return Line?

☐ Yes

☐ No

Size: \_\_\_\_\_ (in)

**9 Comments:** ☐ None

Continuation Page(s) Attached?

☐ Yes

☐ No

\_\_\_\_\_  
Name

\_\_\_\_\_  
Z-Number

\_\_\_\_\_  
Signature

\_\_\_\_\_  
Date

Air Quality Group  
**Transport Line Design**

### Optimum Diameter Worksheet

Form ESH-17-121-18

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

#### 1. Transport System Data:

Flow Rate: \_\_\_\_\_ (cfm) \_\_\_\_\_ (L/min)

Number of Components Including Probe (2 - 30): \_\_\_\_\_

Particle Density: \_\_\_\_\_ (g/cm<sup>3</sup>)

Free Stream Velocity: \_\_\_\_\_ (m/s)

#### 2. Component Information:

Tube: 1. Tube Length (m)  
2. Inclination Angle  
From The Horizontal (°)

Elbow: 1. 90° or 45°

Element	Type (Probe, Tube, Elbow)	1.	2.
1		-----	-----
2			
3			
4			
5			
6			
7			
8			
9			

#### 3. Particle Size Distribution:

☐ Monodisperse Particle Diameter: \_\_\_\_\_ (μm)

☐ Polydisperse

☐ User Defined Discrete  
(Attach Particle Size Distribution)

☐ Log-Normal

Mean Diameter: \_\_\_\_\_ (μm)

GStdD: \_\_\_\_\_

Name \_\_\_\_\_ Z-Number \_\_\_\_\_ Signature \_\_\_\_\_ Date \_\_\_\_/\_\_\_\_/\_\_\_\_



Air Quality Group  
**Transport Line Design**  
**Total Penetration Worksheet**

Form ESH-17-121-19

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. Transport System Data:**

Flow Rate: \_\_\_\_\_ (cfm) \_\_\_\_\_ (L/min)

Tube Diameter: \_\_\_\_\_ (in) \_\_\_\_\_ (mm)

Number of Components Including Probe (1 - 30): \_\_\_\_\_

Particle Density: \_\_\_\_\_ (g/cm<sup>3</sup>)

**2. Component Information:**

Probe: 1. Isokinetic (Y/N)? 2. Free Stream Velocity (m/s) 3. Angle Between Free Stream and Probe Axis (0 - 90°) 4. Probe Diameter If Anisokinetic (mm)	Tube: 1. Tube Length (m) 2. Inclination Angle From The Horizontal (°)	Elbow: 1. 90° or 45°
--	---	----------------------

Element	Type (Probe, Tube, Elbow)	1.	2.	3.	4.
1					
2					
3					
4					
5					
6					
7					
8					
9					

**3. Particle Size Distribution:**

☐ Monodisperse      Particle Diameter: \_\_\_\_\_ (μm)

☐ Polydisperse

☐ User Defined Discrete  
(Attach Particle Size Distribution)

☐ Log-Normal

Mean Diameter: \_\_\_\_\_ (μm)

GStdD: \_\_\_\_\_

Name \_\_\_\_\_ Z-Number \_\_\_\_\_ Signature \_\_\_\_\_ Date \_\_\_\_/\_\_\_\_/\_\_\_\_



Air Quality Group  
**Vacuum System**

Form ESH-17-121-20

TA: \_\_\_\_\_ Building: \_\_\_\_\_ Exhaust Stack: \_\_\_\_\_

**1. System:**

- ☐ Sample Collection \_\_\_\_\_
- ☐ Real-Time Monitor \_\_\_\_\_

**2. Location Description:**

**3. Pump:** VP- \_\_\_\_\_

- ☐ House Vacuum Pump
- ☐ Stand-Alone Vacuum Pump
- Manufacturer: \_\_\_\_\_
- Model Number: \_\_\_\_\_
- ☐ Internal Instrument Vacuum Pump

**4. Pump Maintained By:**

- ☐ ESH-17 ☐ ESH-4
- ☐ Operating Group ☐ \_\_\_\_\_

**5. Flow Rate Indicator:** FI- \_\_\_\_\_

Manufacturer: \_\_\_\_\_

Model Number: \_\_\_\_\_ Range: \_\_\_\_\_

Flow Totalizer: ☐ Yes ☐ No

Flow Alarmed: ☐ Yes ☐ No

Continuation Page(s) Attached? ☐ Yes ☐ No

\_\_\_\_\_  
Name Z-Number Signature Date \_\_\_\_/\_\_\_\_/\_\_\_\_





Air Quality Group <b>Installation Inspection Checklist</b> Page 1, Form ESH-17-121-21			
TA: _____		Building: _____	
		Exhaust Stack: _____	
	Pass	Fail	N/A
<b>1. Probe:</b>			
a. Location	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Alignment	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Markings	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>2. Sampler/Monitor:</b>			
a. Specified Sampler/Monitor	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Installed Correctly	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>3. Transport Lines:</b>			
a. Tube Material	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Tube Diameter	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Radius of Bends	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. Vacuum Test	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>4. Vacuum System:</b>			
a. Connected and Operating	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Sample Flow Rate Correct	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Calibrated	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>5. Electrical:</b>			
a. Hard Wired	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Protected From Weather	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Lightning Protected	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. Backup Power	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>6. Return Lines:</b>			
a. Correct Material	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Adequately Supported	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. Sloped	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<b>7. Labels:</b>			
a. Velocity Measurement Locations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Aerosol Measurement Locations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Sample Probe	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. Vacuum Pump	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e. Flow Rate Indicator	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Air Quality Group  
**Installation Inspection Checklist**

Page 2, Form ESH-17-121-21

	Pass	Fail	N/A
<b>6. Performance Tests:</b>			
a. Particulate Challenge	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Tritium System Test	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**7. Comments:**

SAMPLE

Continuation Page(s) Attached? ☐ Yes ☐ No

☐ Pass ☐ Fail

\_\_\_\_\_  
Name Z-Number Signature Date \_\_\_\_/\_\_\_\_/\_\_\_\_

Air Quality Group																							
<b>Sampling/Monitoring Documentation Checklist</b>																							
Page 1, Form ESH-17-121-22																							
TA: _____		Building: _____																					
		Exhaust Stack: _____																					
Complete	N/A	Task	Documentation Attached																				
<p><b>A. Sampling/Monitoring:</b></p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%; text-align: center;"><input type="checkbox"/></td> <td style="width: 10%; text-align: center;"><input type="checkbox"/></td> <td style="width: 50%;">A.1. Process</td> <td style="width: 30%;">ESH-17-121-01</td> </tr> <tr> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td>A.2. Sampling/Monitoring Requirements</td> <td>ESH-17-121-02</td> </tr> <tr> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td>A.3. Sampler/Monitor</td> <td>ESH-17-121-03</td> </tr> </table>				<input type="checkbox"/>	<input type="checkbox"/>	A.1. Process	ESH-17-121-01	<input type="checkbox"/>	<input type="checkbox"/>	A.2. Sampling/Monitoring Requirements	ESH-17-121-02	<input type="checkbox"/>	<input type="checkbox"/>	A.3. Sampler/Monitor	ESH-17-121-03								
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<p><b>B. Ventilation System:</b></p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%; text-align: center;"><input type="checkbox"/></td> <td style="width: 10%; text-align: center;"><input type="checkbox"/></td> <td style="width: 50%;">B.1. Ventilation System Summary</td> <td style="width: 30%;">ESH-17-121-04</td> </tr> <tr> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td>B.2. Pollution Control Devices</td> <td>ESH-17-121-05 Number: _____</td> </tr> <tr> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td>B.3. Fan Exhaust(s)</td> <td>ESH-17-121-06 Number: _____</td> </tr> <tr> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td>B.4. Exhaust Stack Height, Elevations, and Exit Parameters</td> <td>ESH-17-121-07</td> </tr> </table>				<input type="checkbox"/>	<input type="checkbox"/>	B.1. Ventilation System Summary	ESH-17-121-04	<input type="checkbox"/>	<input type="checkbox"/>	B.2. Pollution Control Devices	ESH-17-121-05 Number: _____	<input type="checkbox"/>	<input type="checkbox"/>	B.3. Fan Exhaust(s)	ESH-17-121-06 Number: _____	<input type="checkbox"/>	<input type="checkbox"/>	B.4. Exhaust Stack Height, Elevations, and Exit Parameters	ESH-17-121-07				
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<p><b>C. Sampling/Monitoring Site Selection:</b></p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%; text-align: center;"><input type="checkbox"/></td> <td style="width: 10%; text-align: center;"><input type="checkbox"/></td> <td style="width: 50%;">C.1. Site Selection</td> <td style="width: 30%;">ESH-17-121-08</td> </tr> <tr> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td>C.2. Cyclonic Flow Analysis</td> <td>ESH-17-121-09</td> </tr> <tr> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td>C.3. Alternative Cyclonic Flow Analysis</td> <td>ESH-17-121-10</td> </tr> <tr> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td>C.4. Flow Measurement Location</td> <td>ESH-17-121-11</td> </tr> </table>				<input type="checkbox"/>	<input type="checkbox"/>	C.1. Site Selection	ESH-17-121-08	<input type="checkbox"/>	<input type="checkbox"/>	C.2. Cyclonic Flow Analysis	ESH-17-121-09	<input type="checkbox"/>	<input type="checkbox"/>	C.3. Alternative Cyclonic Flow Analysis	ESH-17-121-10	<input type="checkbox"/>	<input type="checkbox"/>	C.4. Flow Measurement Location	ESH-17-121-11				
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<p><b>D. Sample Extraction:</b></p> <table style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 10%; text-align: center;"><input type="checkbox"/></td> <td style="width: 10%; text-align: center;"><input type="checkbox"/></td> <td style="width: 50%;">D.1. Sample Extraction Methodology Selection</td> <td style="width: 30%;">ESH-17-121-12</td> </tr> <tr> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td>D.2. Flow and Mixing Characteristics</td> <td>ESH-17-121-13</td> </tr> <tr> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td>D.3. Engineering Studies</td> <td>ESH-17-121-14</td> </tr> <tr> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td>D.4. ANSI Sample Probe</td> <td>ESH-17-121-15</td> </tr> <tr> <td style="text-align: center;"><input type="checkbox"/></td> <td style="text-align: center;"><input type="checkbox"/></td> <td>D.5. Single-Point Shrouded Sample Probe</td> <td>ESH-17-121-16</td> </tr> </table>				<input type="checkbox"/>	<input type="checkbox"/>	D.1. Sample Extraction Methodology Selection	ESH-17-121-12	<input type="checkbox"/>	<input type="checkbox"/>	D.2. Flow and Mixing Characteristics	ESH-17-121-13	<input type="checkbox"/>	<input type="checkbox"/>	D.3. Engineering Studies	ESH-17-121-14	<input type="checkbox"/>	<input type="checkbox"/>	D.4. ANSI Sample Probe	ESH-17-121-15	<input type="checkbox"/>	<input type="checkbox"/>	D.5. Single-Point Shrouded Sample Probe	ESH-17-121-16
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Air Quality Group			
<b>Sampling/Monitoring Documentation Checklist</b>			
Page 2, Form ESH-17-121-22			
Complete	N/A	Task	Documentation Attached
<b>E. Transport Line</b>			
<input type="checkbox"/>	<input type="checkbox"/>	E.1. Transport Line Design	ESH-17-121-17
	<input type="checkbox"/>	E.1.A Optimum Diameter Worksheet	ESH-17-121-18
	<input type="checkbox"/>	E.1.B. Total Penetration Worksheet	ESH-17-121-19
<b>F. Vacuum System</b>			
<input type="checkbox"/>	<input type="checkbox"/>	F.1. Vacuum System	ESH-17-121-20
<b>G: Installation Requirements and Inspection:</b>			
<input type="checkbox"/>	<input type="checkbox"/>	G.1. Installation Inspection Checklist	ESH-17-121-21
<b>H. Documentation:</b>			
<input type="checkbox"/>	<input type="checkbox"/>	1. Sampling/Monitoring Documentation Checklist	ESH-17-121-22
<input type="checkbox"/>	<input type="checkbox"/>	2. Approved Variance Request	ESH-17-121-24
<input type="checkbox"/>	<input type="checkbox"/>	<b>I. Comments:</b> <input type="checkbox"/> None	
Continuation Page(s) Attached? <input type="checkbox"/> Yes <input type="checkbox"/> No			
I Certify That This Sampling System Has Been Installed In Accordance With ESH-17-121.			
Name _____		Z-Number _____	Signature _____ Date ____/____/____
<input type="checkbox"/> Approved <input type="checkbox"/> Disapproved			
Emissions Measurement Team Leader _____		Z-Number _____	Signature _____ Date ____/____/____
<input type="checkbox"/> Approved <input type="checkbox"/> Disapprove			
Quality Assurance Team Leader _____		Z-Number _____	Signature _____ Date ____/____/____

Air Quality Group  
**Continuation Page**

Form ESH-17-121-23

FORM: ESH-17-121- \_\_\_\_

Page \_\_\_\_ of \_\_\_\_

SAMPLE



Air Quality Group  
**Variance Request**

Form ESH-17-121-24

TA: \_\_\_\_\_

Building: \_\_\_\_\_

Exhaust Stack: \_\_\_\_\_

SAMPLE

Continuation Page(s) Attached? ☐ Yes ☐ No

Submitted By:

\_\_\_\_\_  
Name Z-Number Signature Date \_\_\_\_/\_\_\_\_/\_\_\_\_

Recommend: ☐ Approval ☐ Disapproval

\_\_\_\_\_  
Emissions Measurement Team Leader Z-Number Signature Date \_\_\_\_/\_\_\_\_/\_\_\_\_

☐ Approved ☐ Disapproved

\_\_\_\_\_  
ESH-17 Group Leader Z-Number Signature Date \_\_\_\_/\_\_\_\_/\_\_\_\_